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ABSTRACT

The curriculum guide for electronics is one of five guides written and field tested in a project to develop statewide articulated competency-based curricula in selected vocational education programs. Curricula are presented for three separate levels: secondary electronics, postsecondary electronic technology, and an associate degree program in engineering technology. The two-year high school program provides a technical background for further training or entry into the trade at an apprentice level. Following a course outline, 67 tasks are presented, with performance objectives and a criterion-referenced measure for each. Job opportunities are described following completion of each of three phases of required tasks. Curriculum format for the postsecondary and associate degree levels are similar. For each task, a performance objective and criterion-referenced measure is given. A description of the criterion-referenced measure is followed by a performance guide for theory and for laboratory, with suggested hours frequently given for each. A bibliography is included. (RG)

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COMPETENCY - Based Curriculum

for

ARTICULATED Programs

in

Electronics

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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PURPOSE OF THE STUDY

The Bureau of Vocational Education, Louisiana State Department of Education was awarded a grant to make a study for the articulation of competency-based curricula for the coordination of selected vocational-technical education programs. The five areas selected for study and development of competency-based curricula were: (1) Air-conditioning/Refrigeration, (2) Drafting, (3) Electronics, (4) Nursing, and (5) Office Occupations.

A team of writers worked during the Summer of 1975 developing curricula or guides for teachers on the three institutional levels: Secondary, Post-Secondary, Vocational-Technical, and Associate Degree programs on the collegiate level.

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INTRODUCTION

The material presented in this two-year high school electronics program is directed toward the average student. Emphasis is placed on application of electronic theory. An understanding of the basic mathematical operations, algebra and trigonometry, is desirable. As the student progresses through the course, essential mathematical concepts are emphasized. It is the intent of this course to encourage the student with a less than adequate mathematical background to succeed in electronics. This is achieved through the extensive use of experiments and hands-on experiences. Safety is an integral component of each task and is emphasized repeatedly to the student as progress is achieved throughout the course.

It is the objective of this course to provide the average student with a wide background of experiences in basic electronics during the first year. Emphasis is placed on the use of passive components, practical circuit analysis and diagnosis of basic circuits. Progress in the second year is correlated between basic circuits and the areas of audio (tape players), radio and television. Re-emphasis of the basic circuits is achieved through hands-on experience in diagnosis and repair of live work.

This competency-based curriculum in electronics is presented for possible implementation at the high school level. Its flexibility is limited only by the goals of the instructor. Use of breadboard instruction such as nickok or Lab-Volt can be used to achieve many of the competency-based tasks.

This curriculum does not produce a certified technician. It permits the student to make a realistic career decision as to potential success in electronics and provides a technical background for further training after completion of high school. The student is able to enter the trade at the apprentice level.

ELECTRONICS FOR HIGH SCHOOL STUDENTS

BASIC ELECTRONICS, RADIO AND TV

FIRST YEAR

I. Basic Direct Current Theory

- A. Electron Theory
- B. Energy Sources
- C. Ohm's Law
- D. Conductors and Nonconductors
- E. Simple Schematics
- F. The Series Circuit
- G. The Parallel Circuit
- H. The Analysis of Passive DC Circuits

II. The Operation and Application of Basic Measuring Devices

- A. The Galvanometer
- B. The Ammeter
- C. The Ohmmeter
- D. The Multimeter
- E. The Oscilloscope

III. Fundamental Passive Components

- A. Resistor Characteristics
- B. Resistor Color Code
- C. Capacitor Characteristics
- D. Capacitor Color Code
- E. Inductor Characteristics
- F. Capacitors or Inductors in Series
- G. Capacitors or Inductors in Parallel
- H. Time Constants

IV. Alternating Current Theory

- A. The Sine Wave
- B. Instantaneous, Peak and RMS Values of Voltage
- C. Instantaneous, Peak and RMS Values of Current
- D. Inductive and Capacitive Reactance
- E. Vectors
- F. Impedance
- G. Resonance
- H. Series Circuits
- I. Parallel Circuits
- J. Power

V. Application of the Oscilloscope

A. Familiarization with Operational Procedures
B. Limitations and Advantages
C. Voltage Interpretations
D. Waveform Interpretations
E. Frequency Interpretations

VI. Vacuum Tubes

A. Thermonic Emission
B. Diode Characteristics
C. Triode Characteristics
D. Tetrode Characteristics
E. Pentode Characteristics
F. Gas Tubes
G. Cathode-Ray Tube

VII. Semiconductors

A. Current Carriers
B. Bias
C. The PN Junction Characteristics
D. Transistor Characteristics
E. PNP and NPN
F. Circuit Parameter Measurements
G. Biasing and Stabilization

VIII. Schematics

A. Amplifier Block Diagrams
B. Tape Player Block Diagrams
C. Radio Block Diagrams

IX. Power Supplies

A. The Transformer
B. Half-Wave Rectification
C. Full-Wave Rectification
D. Voltage Doublers
E. Bridge Rectification
F. Filters
G. Regulators

X. Amplifiers

A. Voltage Amplifiers
B. Current Amplifiers
C. Power Amplifiers
D. Coupled Amplifiers
E. Frequency Characteristics of Amplifiers
F. Distortion Analysis of Amplifiers

XI. Oscillators

A. Armstrong
B. Hartley
C. Colpitts
D. Multivibrator
E. Crystal
F. [illegible]

XII. Receivers

A. Wave Propagation
B. Antennas
C. Tuned Circuits
D. Detectors
E. Superheterodyne Receiver

SECOND YEAR

I. Business Procedures

A. Customer Relations
B. Advertising
C. Estimate of Repairs
D. Financing
E. Display
F. Service Orders
G. Set Identification
H. Invoicing and Billing

II. Test Instruments

A. Equipment Safety
B. Basic Test Instruments
C. Signal Tracers
D. Oscilloscopes
E. Signal Generators
F. Human Sensors

III. Amplifiers

A. Safety
B. Block Diagram
C. Transducers
D. Controls
E. Preamplifiers
F. Voltage Amplifiers
G. Power Amplifiers
H. Troubleshooting

IV. Superheterodyne Receivers

A. Safety
B. Block Diagrams
C. Controls
D. Antennas
E. RF Amplifiers
F. Mixers
G. IF Amplifiers
H. Detectors
I. Audio Amplifiers
J. Power Supplies
K. Troubleshooting

V. Monochrome TV Receivers

A. Safety
B. Introduction to Television Theory
C. Block Diagram
D. Controls
E. The Tuner
F. The IF Amplifiers
G. The Video Amplifiers
H. The Audio Amplifiers
I. The Sync and AGC Amplifiers
J. Vertical and Horizontal Deflection Circuitry
K. Power Supplies
L. Troubleshooting

VI. Color Television Receivers

A. Safety
B. Block Diagram
C. Controls
D. Convergence Procedures
E. Picture Tube Testing
F. Troubleshooting

Task 1: Introduction to Basic Direct Current Theory Analysis

Performance Objectives:

Given paper, pencil and no references, the learner is to:

1. Analyze a passive DC circuit. The circuit consists of a source of energy, a method of controlling the flow of energy, a method of transporting the energy and a resistive load.
2. Identify the direct sources of energy.
3. List the characteristics of conductors and nonconductors.
4. Draw and analyze simple schematics using Ohm's Law as applied to series or parallel circuits.

Criterion-Referenced Measure: The learner is to complete the analysis within two hours with a minimal standard of 80 percent accuracy. The learner is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Task 2: Introduction to Electricity

Performance Objectives:

Given verbal instructions, the student is to:

1. List the need for the theory of electricity, wave propagation, sound, and light.
2. Work the math that is needed to solve the basic concepts of electricity.

Criterion-Referenced Measure: Each student will be tested to measure his progress to at least 80 percent accuracy. The learner is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal. He must be able to show the relationship between basic electricity and math.

1. Written test
2. Oral drills
3. Class discussion

Performance Guide:

1. The use of electricity as a source of energy
2. Electronics
3. Need for a knowledge of electricity
4. Wave propagation
5. Sound
6. Light
7. Prerequisite math
   A. Number system
   B. Arithmetic operations
   C. Exponents and radicals
   D. Power of ten
   E. Basic Algebra

Task 3: Soldering and Hand Tools

Performance Objective:

The student will identify the correct use for hand tools and soldering techniques that are necessary for electronic repairs.

Criterion-Referenced Measures: Each student will be able to solder various connections in a chassis. He will be able to wire and splice various sizes of wire, use the hand tools in the correct manner, use the correct soldering procedures and all safety rules. He must be able to achieve 100 percent accuracy.

Performance Guide:

1. The soldering gun
2. The soldering pencil
3. The tools of the trade
   A. Diagonal cutters
   B. Long nose pliers
   C. Spin tights
   D. Screw drivers
   E. Reamers
   F. Adjustable wrench
4. The use of the chassis
5. The use of the chassis punch
6. The terminal strip
7. Splicing of wires
8. Safety

Task 4: Theory of Electricity

Performance Objective:

Given the equipment listed below, the student will be able to list the basic concepts of magnetism, electricity, electronics, and the EIA color code for resistors.

Equipment:

1. Various sizes of resistors
2. Bar magnet
3. Galvanometer
4. Iron filings

Given a lab assignment, the student will be able to:

1. Demonstrate two ways of generating EMF.
2. Apply the EIA color code when given a tray of assorted resistors.

Criterion-Referenced Measure: The student will show by written test and by demonstrating that he can apply to at least 85 percent accuracy the basic concepts of electrical theory and the EIA color code to 100 percent accuracy. He will be allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Performance Guide:

1. Atomic structures
2. Conductors
3. Electrostatics
4. Magnetism
5. EMF
6. Methods of producing EMF
7. Electric current
8. Resistance - EIA color code
9. Symbols and abbreviations

Task 5: Direct Current Circuits

Performance Objectives:

Given the equipment listed below, the student will be able to:

1. Solve a problem for the current, voltage and resistance in a series, parallel and compound circuit.
2. Hook up his circuit and prove that his calculations are correct.

Equipment:

1. Large chassis
2. Power supply: 0 to 400 volts
3. Assorted sizes of resistors
4. Terminal strips
5. Soldering gun or pencil
6. Volt, Ohm, Ammeter
7. Bread board and fanstock clips

Given a lab assignment, the student will be able to:

1. Wire a series and parallel circuit in his chassis to prove that the calculations that he has done in the classroom are correct.
2. Show the correct procedures and safety precautions while using the VOM.
3. Show the proper way to use the VOM to 100 percent accuracy.

Criterion-Referenced Measures: The student will be tested to show the basic DC circuit laws, how to calculate the current, voltage and resistance in a series, parallel, and combination circuit. His soldering technique will be observed to check his progress. He must be able to achieve a minimal standard of 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Performance Guide:

1. The simple circuit
2. Factors governing current flow
   A. Voltage
   B. Resistance
3. The nature of resistance
4. Series circuits
5. Parallel circuits
6. Combination circuits
7. Voltage dividers
8. How to use the VOM
9. Safety

Task 6: Batteries and Cells

Performance Objectives:

Given the equipment listed below, the student will be able to:

1. Measure the voltage and check the condition and proper care of the various types of cells.
2. Series and parallel connect various types of cells.

Equipment:

1. Lead acid storage cell
2. Hydrometer
3. Various sizes of dry cells
4. 6.3 volt lamp (47 or 1897 lamps)
5. Hook-up wire, solder

Given a lab assignment, the student will be able to:

1. Demonstrate how to series connect and parallel connect the batteries when given two bulbs.
2. Show how to use the hydrometer.

Criterion-Referenced Measure: The student will be tested to show his ability to tell the types of cells, their voltage, and proper care, to at least 80 percent accuracy by the use of a: (1) written test, (2) oral test, or (3) performance test. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Performance Guide:

1. Types of Cells
   A. Primary
      (1) Galvanic cells
      (2) Dry cells
      (3) Mercury cells

B. Secondary Cells
(1) Lead acid
(2) Nickel cadium
(3) Nickel iron
2. Cells in combination
3. Battery maintenance
4. New development

Task 7: Magnetism and Electromagnetism

Performance Objective:

The student will illustrate and define the basic magnetic and electromagnetic laws and theory by using the following equipment.

Equipment:

1. Bar magnet
2. Iron filings
3. Compass
4. Small gauge wire
5. Power supply 0 to 40 volt Hickok 550 or equivalent

Given a lab assignment, the student will be able to:

1. Prove with the equipment stated above the basic laws of magnetism and electromagnetism.
2. Prove that what has been stated in class is a fact.

Criterion-Referenced Measure: The student will be tested to prove that he can list the basic laws and theories of magnetism. He must demonstrate a minimal standard of 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Performance Guide:

1. Magnetic fields about a conductor
2. Magnetic field of a coil
A. Field strength
B. Magnetomotive force
C. Flux path
D. Reluctance
3. Applications of electromagnets

Task 8: The Operation and Applications of Basic Measuring Devices

Performance Objectives:

Given paper, pencil, Galvanometer, Ammeter, Voltmeter, Ohmmeter, Multimeter, a passive circuit and no references, the learner will be able to:

1. Identify in writing each basic measuring device and list its characteristics.
2. Connect each measuring device correctly to the passive circuit.
3. Write the value indicated by the pointer on the scale.
4. Write the value indicated by the pointer on measuring devices which have more than one scale.
5. Write the value indicated by the pointer on measuring devices which have more than one scale and a range switch.
6. Write the value indicated by the pointer on a measuring device, select the correct range position and the correct function position of the range and function switch(es).

Criterion-Referenced Measure: The learner is to complete all measurements and listing within two hours with a minimal standard of 80 percent accuracy. The learner is allowed to repeat until he achieves personal goal beyond instructor's goal.

Task 9: Meters: How to Use Them and How They Work

Performance Objectives:

Given an ohmmeter, ammeter, and a multimeter, every student in electronics must be able to:

1. Use meters and repair them if they become inoperative.
2. Outline the operation, the safety procedures, and the correct use of each.

Given one chassis, one meter and assorted components, the student will be able to:

1. Make an ammeter, ohmmeter, and voltmeter.
2. Calculate all values and components that are needed to accomplish the task.
3. Wire up the meters in the chassis.
4. Follow all safety rules to make certain the equipment is used in the right manner. (Have all work checked by instructor)

Criterion-Referenced Measure: Each student will be tested to make sure that he can write all the laws, the proper use, and the care of all the meters covered in this unit of instruction. The student must achieve a minimal standard of 80 percent accuracy but is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal on this unit by: (1) written tests, (2) oral drills, and (3) performance tests.

Performance Guide:

1. Ammeter
   A. D'Arsonval Meter Movement
   B. Deflection sensitivity
   C. Meter scales
   D. Ammeters
   E. Multirange meters
   F. Ammeter construction
   G. Care of meters
   H. Mathematics
2. Voltmeter
   A. Voltmeter theory of operation
   B. Voltmeter multiplier
   C. Voltmeter construction
   D. Care of voltmeters
3. Ohmmeters
   A. Ohm's Law in ohmmeters
   B. The series ohmmeter
   C. Shunt type ohmmeter
   D. Care of ohmmeters
   E. Mathematics
4. Multimeter
   A. Care of multimeters
   B. Safety precautions when using multimeters

Task 10: Miscellaneous Measuring Devices

Performance Objectives:

Given the equipment listed below, the student will be able to:

1. Identify other measuring devices used in electronic service work.
2. Use the devices correctly and apply all the safety rules while using the equipment.

Equipment:

1. Multimeter
2. Wheatstone
3. Megohmmeter
4. VTVM (Vacuum Tube Volt Meter)
5. Tube tester
6. Transistor tester
7. Digital measuring devices (voltmeter, ohmmeter, frequency counter)

Criterion-Referenced Measure: The student will be tested to be certain that he can use the equipment in the proper manner, and that he can apply all the safety rules. He must be able to achieve 90 percent accuracy on this unit but is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal by the use of: (1) written test, (2) oral tests, or (3) performance tests.

Performance Guide:

1. Multimeter
2. Vacuum tube voltmeter
3. Wheatstone bridge
4. Megohmmeter
5. Tube testers
6. Transistor testers
7. Oscilloscope

Task 11: Fundamental Passive Components

Performance Objectives:

Given resistors, capacitors, inductors, ohmmeter, capacitance and inductance tester, paper, pencil and no references, the learner is to:

1. Write the values of a selected number of different resistors and the tolerance and power capability of each resistor.
2. Write the total combinational value of a selected number of resistors of the same value connected in series or parallel or combinations of series and parallel.
3. Write the total value of a selected number of different resistors connected in series.
4. Write approximate total value to within 25 percent accuracy of a selected number of different resistors connected in parallel.
5. Measure and record by using an ohmmeter any combination of resistors connected in series, parallel or both, to within component tolerance.
6. Repeat above procedure for capacitors and inductors.
7. Use capacitance tester or the inductance tester correctly for these measurements.

Criterion-Referenced Measure: The learner is to complete writings and measurements within two hours with a minimal standard of 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Task 12: Introduction to Trigonometry

Performance Objective:

Given paper and pencil, the student will be able to apply the mathematics needed to solve AC problems in electronic circuits.

Criterion-Referenced Measure: The student will be tested to make sure that he can solve a right triangle using trigonometry and applying it to AC electrical circuits.

Performance Guide:

1. Angles
   A. Generation of angles
   B. Angular measurement
2. Similar triangles
3. The right triangle
4. Facts about triangles
5. Trigonometric ratios
6. Solving right triangles
7. Sine function
8. Amplitude
9. Frequency
10. Period
11. Phase
12. Problem solving session

Task 13: Alternating Current Fundamentals

Performance Objective:

The volume of energy produced for commercial application makes the study of alternating current very important to the electrician. All electronic circuits are based upon alternating current phenomena. The study of alternator theory and the commercial applications of alternating current are of utmost importance. Using the above information, the student is to list all the phenomena and theory of alternating current.

Criterion-Referenced Measure: The student will be tested to prove that he can list alternator theory and phenomena to at least 80 percent accuracy.

Performance Guide:

1. Alternator theory
2. Variation of alternating EMF
3. Frequency spectrum
4. Hertz
5. AC values
6. Measuring alternating current
7. Mathematics

Task 14: Laws and Properties of Inductance

Performance Objective:

Given paper, pencil and no references, the student will be able to list the laws and properties of inductance in order to apply this important circuit phenomenon.

Criterion-Referenced Measure: The student will be tested to make certain he can apply the laws and properties of inductance, and can solve LR circuit impedance to at least 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Performance Guide:

1. Definitions
   A. Inductor
   B. Inductance
   C. Counter EMF
   D. Henry
2. Theory of inductance
3. Physical aspects
4. Series and parallel combinations
5. Inductive reactance
6. Inductance and resistance
7. Impedance
8. Problem solving session

Task 15: Transformers

Performance Objective:

Using the material provided, the student will be able to outline and illustrate the action of a transformer in electronic circuits.

Criterion-Referenced Measure: The student will be tested with a written test to check his progress to at least 80 percent accuracy. He will also be given a performance test to check his ability to work with transformers.

Performance Guide:

1. Magnetic induction
2. Transformer action
3. Power in transformer circuits
4. Transformer construction
5. Transformer losses
6. Considerations

Task 16: Laws and Properties of Capacitance

Performance Objectives:

1. The student will be introduced to the laws and properties of capacitance in order that he may apply this important circuit phenomenon.

Criterion-Referenced Measure: The student will be tested to make sure that he can apply the laws and properties of capacitance to at least 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Capacitance and factors affecting capacitance
2. Capacitor ratings
3. Capacitor combinations
   A. Series
   B. Parallel
4. The RC time constant
5. Types of fixed capacitors
   A. Mica
   B. Paper
   C. Ceramic
   D. Synthetic film
   E. Electrolytic
6. Variable capacitors

Task 17: Alternating Current Theory

Performance Objectives:

Given paper, pencil and no references, the learner is to:

1. Draw a sine wave and identify frequency, period and wave length.
2. Draw and define instantaneous, peak and RMS values of voltage and current.
3. Define inductive and capacitive reactance.
4. Solve simple circuits using inductors or capacitors or both inductors and capacitors.
5. Draw and define a vector.
6. Define impedance.
7. Define power, true power, apparent power and power factor.

Criterion-Referenced Measure: The learner is to complete the definitions, drawings and calculations within two hours to at least 80 percent accuracy but may repeat until he achieves personal goal beyond acceptable instructor's goal.

Task 18: AC Circuits

Performance Objectives:

Given proper material, the student will be able to:

1. Solve problems in series and parallel and combination AC circuits.
2. Outline all AC circuit action.

Criterion-Referenced Measure: The student will be tested to make sure that he can solve AC circuit impedance, power factor, and power consumption. He will also be tested to solve resonant frequency problems. He must be able to achieve at least 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Performance Guide:

1. AC circuits
2. Reactance
   A. Inductive
   B. Capacitive
3. Phase relations
4. Vector representations
   A. Rotating vectors
   B. J operator
   C. Elementary vector algebra
5. Impedance
6. Power consumption
7. Series AC circuits
   A. Capacitive circuits (ICE)
   B. Inductive circuits (ELI)
   C. Resonance
8. Parallel AC circuits
   A. Capacitive
   B. Inductive
   C. Resonance
9. Frequency spectrum

JOB OPPORTUNITIES AFTER COMPLETION OF BASIC ELECTRICITY

ELECTRONICS ASSEMBLER

Bench assembler; electromechanical assembler; electronic unit assembler; utility operator; wireman. Connects lead wires of components such as resistors, capacitors, transistors, diodes, and rectifiers to specified terminals using soldering iron or spot welder. Routes and fastens precut jumper wires and cables to specified contact points following wiring diagram and wire list, to form circuit wiring. Test circuits for shorts and open wires using ohmmeters. May cut and strip wires, using wire cutters to prepare jumper wires and cables. May resolder connections or replace defective components and wiring, following instructions of testing or inspection personnel to repair defective equipment.

Task 19: Application of the Oscilloscope

Performance Objectives:

Given instructions for operating an oscilloscope, a function generator and test leads, the learner must:

1. List in writing all controls and their functions without the use of the instruction manual.
2. List three advantages and three disadvantages in using the oscilloscope.
3. Identify basic waveshapes, label frequencies and measure voltages.
4. Use the ringing test to check for defects in inductors.

Criterion-Referenced Measure: The learner is to complete measurements, identifications, listings and drawings within two hours to within 75 percent accuracy for D; 80 percent accuracy for C; 90 percent accuracy for B; 96 percent accuracy for A. The learner is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Task 20: Introduction to Vacuum Tubes

Performance Objectives:

Given paper, pencil, tubes consisting of diodes, triodes, tetrodes, pentodes, gas tubes and cathode ray tubes, the learner must:

1. Define thermonic emission.
2. List the characteristics of the tube types given.

Given a vacuum tube tester and a cathode ray tube tester, the student must:

1. Write the correct operating procedure for each.
2. Construct a chart.
3. Test all tubes indicating identifying number, function, defects and quality.

Criterion-Referenced Measure: The learner is to complete all measurements, definitions and listing within two hours to within 75 percent accuracy for D; 80 percent accuracy for C; 90 percent accuracy for B; 96 percent accuracy for A. All measurements are to be repeated until in agreement with instructor. All listings and definitions are to be repeated until 80 percent accuracy is achieved prior to entering next unit of study. The learner is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Task 21: Vacuum Tubes

Performance Objectives:

Given needed material, the student will:

1. Demonstrate the theory of vacuum tubes.
2. Show how the diode, triode, tetrode, and pentode tube is used in electronic circuits.
3. Wire different circuits to prove tube circuit theory.

Criterion-Referenced Measure: The student will be tested with a written test to measure his progress in application of the theory of vacuum tubes to a minimal standard of 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal. He will also be given a performance test to make certain that he can work with vacuum tubes in a live circuit. He will show with training equipment that he can wire various vacuum tube circuits.

Performance Guide:

1. Edison effect
2. Emission of electrons
   - A. Thermonic emission
   - B. Photoelectric
   - C. Secondary emission
   - D. Cold cathode
3. The diode tube
   - A. Construction of diode
   - B. Physical construction
   - C. Operation of diode
   - D. Tube socket and base
4. Mathematics
5. The triode
   - A. Construction of the triode
   - B. Operation of the triode
     - (1) Control grid action
     - (2) Bias
   - C. Tube characteristics
     - (1) Amplification factor
     - (2) Plate resistance
     - (3) Transconductance
6. The triode as a variable resistor
7. The tetrode
   - A. Construction
   - B. Operation
8. The pentode
   - A. Construction
   - B. Operation
9. Mathematics

Task 22: Introduction to Transistors

Performance Objective:

Given needed material, the learner must:

1. Show basic transistor theory.
2. Show operation of basic transistor circuits.

Criterion-Referenced Measure: The student will be tested to measure his progress and application of basic transistor theory to at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Performance Guide:

1. General definitions
2. Current carriers
3. Transistor materials
4. PN junctions
5. PN diode
   A. PN diode bias
   B. PN diode characteristics
   C. PN rectifier
   D. Zener effect
   E. Zener diode
6. Tunnel diode
7. Basic transistor

Task 23: Semiconductors

Performance Objectives:

Given transistor data manual, transistor tester instruction manual, an assortment of transistors, transistor tester(s) and an ohmmeter, the learner must:

1. Define minority and majority current carriers, forward and reverse bias, PN, PNP and NPN junctions.
2. List major transistor characteristics and parameter measurements utilized in transistor tester(s).
3. Draw schematically and define the types of biasing and methods of stabilization.
4. List the sequence necessary for testing transistors when using an ohmmeter or when using a transistor tester.
5. Construct a chart having transistor number, function, leakage(s), quality and replacement.
6. Use instruments provided to test transistors and record data on chart.

Criterion-Referenced Measure: The learner is to complete measurements, definitions, listings, drawings and charts within two hours to a minimal of 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal. All measurements are to be in agreement with those of the instructor.

Task 24: Transistor Theory and Typical Circuits

Performance Objectives:

With the material provided, the student will:

1. Illustrate transistor theory and general circuits now in use.
2. Show how to check the transistor with the proper equipment.
3. Show how to remove and replace the transistor in the correct manner without damage to the circuits.

Criterion-Referenced Measure: The student will be tested to measure his progress on transistor theory, and how to check them, and replace them in the correct manner. He must achieve at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond acceptable instructor's goal.

Performance Guide:

1. Amplification
2. Input-output circuit interaction
3. Transistor gain
4. Common emitter transistor amplifier
5. Common base transistor amplifier
6. Common collector transistor amplifier
7. Current, voltage, power gains
8. Comparison of characteristics
9. Characteristic curves
10. Power
11. Typical transistor data
12. Safety precautions

Task 25: Integrated Circuits

Performance Objective:

Given material provided by the instructor, the student will:

Illustrate basic integrated circuits, how to use them, how to remove them from the circuit and how to replace them in the proper manner.

Criterion-Referenced Measure: The student will be tested to measure his ability to work with integrated circuits, and how to replace them without damage to the circuits achieving 100 percent accuracy.

Performance Guide:

1. Basic processes
2. Thin-film techniques
3. Semiconductor techniques
4. Silicon processes
5. Comparison with discrete components
6. Integrated circuits applications
7. Safety precautions

Task 26: Schematics

Performance Objectives:

Given SAMS photofact index, photofact schematics, manufacturer data, paper or block diagram format and any home entertainment amplifier, tape player or radio, the learner must:

1. Identify: brand, model number, serial or chassis number, SAMS index number or manufacturer data.
2. Record function of each tube(s) or transistor.
3. Make flow of data from sensor (antenna, cartridge or tape head) to reproducer (speaker) agree with that of the instructor.

Criterion-Referenced Measure: The learner is to record identifying data, block diagram with functions in correct sequence without references except SAMS photofact index and schematic. This must be repeated for any home entertainment unit until in consistent agreement with instructor.

Task 27: Introduction to Power Supplies

Performance Objective:

With the material provided, the student will show the use of the transformer, half-wave rectifier operation, full-wave operation and filter circuit operation.

Criterion-Referenced Measure: The student will be tested to measure his progress to at least 80 percent accuracy in the use of power supplies. He is allowed to repeat until he achieves personal goal beyond acceptable goal of the instructor. He will be given a performance test to make sure that he can work with power supplies in real live equipment.

Performance Guide:

1. Use of the transformer
2. Half-wave rectifier operation
3. Full-wave operation
4. Peak inverse voltage
5. Filter circuits
   A. Capacitance filter
   B. Inductance filter
   C. Filter combinations
6. Review

Task 28: Power Supplies

Performance Objectives:

Given any schematic, a power supply, voltmeter, ohmmeter, oscilloscope, the learner must, without aid of references:

1. Define the components of a power supply.
2. Draw schematically and explain each of the following functions: half-wave, full-wave, voltage doubler and bridge.
3. Draw schematically and explain the "L type" and the "PI" filter.
4. Draw schematically and explain how a voltage regulator works using zeners, VR tubes or vacuum tubes.
5. Identify the type power supply used, measure reference voltages and verify waveforms.
6. Correct malfunction in power supply of any home entertainment amplifier, tape player or radio.

Criterion-Referenced Measure: The learner is to complete definitions, schematics, explanations and measurements within two hours to a minimal standard of 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Task 29: Rectifiers, Voltage Dividers, Regulators, and Voltage Doublers

Performance Objective:

Provided with needed material, the student will demonstrate electron tube and dry-metal rectifiers, voltage divider, regulators and voltage doublers circuit configuration.

Criterion-Referenced Measure: The student will be tested to measure his progress to at least 80 percent accuracy on voltage doublers, regulators and rectifiers. He may repeat until he achieves personal goal beyond instructor's goal. He will be given a performance test to check his progress and ability to work on live power supplies, and to troubleshoot supplies.

Performance Guide:

1. Electron tube and dry-metal rectifiers
   A. Mercury vapor rectifiers
   B. Selenium rectifiers
   C. Circuit arrangements
2. Voltage dividers
   A. Divider with load
   B. Bleeder resistor
   C. Voltage divider resistor
3. Regulator circuits
4. Voltage regulator tubes
5. Half-wave voltage doublers
6. Full-wave voltage doublers
7. Half-wave cascade voltage doublers
8. Voltage triplers
9. Bridge circuits
10. Bridge doublers
11. Troubleshooting

Task 30: Amplifiers

Performance Objectives:

Given any schematic, amplifier, voltmeter, ohmmeter, oscilloscope, signal generator and function generator, the learner is to, without aid of references:

1. Explain how any of the following amplifiers function and draw its schematic, voltage, current, and power.
2. Explain the types of biasing which can be used.
3. Explain the types of coupling which may be used to connect amplifier stages together.
4. List the frequency characteristics necessary for a good amplifier.
5. List the types of distortion which may be generated in an amplifier.

Given any home entertainment amplifier, tape player or radio and a standard tool kit, the student must:

1. Record the following data: deviation from reference voltages and resistances, amount of amplification provided by amplifier stage and distortions.
2. Analyze difficulty in a malfunctioning home entertainment system and return it to acceptable working condition.

Criterion-Referenced Measure: The learner is to complete definitions, listings and explanations within two hours to a minimal standard of 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Task 31: Amplifiers and Oscilloscopes

Performance Objective:

With the equipment and material provided, the student will demonstrate the amplifier and the correct use of the oscilloscope.

Criterion-Referenced Measure: The student will be tested to measure his progress to at least 80 percent accuracy his ability to work with basic amplifiers. He may repeat until he achieves personal goal beyond instructor's goal. He will be given performance test to show his ability to use the oscilloscope to within 100 percent of the instructor demands and his ability to wire various tube circuits and check the frequency response, voltage and power amplifications.

Performance Guide:

1. The amplifier
2. Classification of amplifiers
   - A. Frequency
   - B. Voltage and power
   - C. Operating level
     - (1) Class A
     - (2) Class B
     - (3) Class C
     - (4) Class AB and AB_1
3. The basic tube amplifier
4. Method of bias
   - A. Cathode bias
   - B. Self bias
   - C. External bias
5. The oscilloscope
   - A. Cathode ray tube
   - B. Beam formation
   - C. Deflection
   - D. Production of screen trace
   - E. Use of the oscilloscope

Task 32: Types of Amplifiers

Performance Objective:

Provided with needed material, the student will demonstrate the different types of amplifiers, their use and how to troubleshoot various circuit configurations.

Criterion-Referenced Measure: The student will be tested to make sure that he outlines the material covered on amplifier types. He will be tested by troubleshooting and using test equipment. He must obtain at least 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Triode RC coupled amplifiers
   A. Single stage amp
   B. Two stage amp
2. Transformer coupled amplifier
3. Impedance coupled amplifier
4. Direct coupled amplifier
5. Pentode amplifiers
   A. RC coupled
   B. Transformer coupled
   C. DC coupled

Task 33: Amplifier Circuits

Performance Objective:

With the equipment provided, the student will demonstrate the various amplifier circuits and how to troubleshoot them with the correct test equipment.

Criterion-Referenced Measure: The student will be tested to measure his ability to troubleshoot amplifiers with the correct test equipment. He will take a written test to measure his capabilities to at least 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Harmonics
2. Wave forms
   A. Square wave
   B. Sawtooth waves
   C. Peaked waves

3. Distortion
   A. Frequency distortion
   B. Phase distortion
   C. Amplitude distortion
   D. Crossover distortion
4. Controls
   A. Volume
   B. Tone
5. Loudspeakers
   A. Dynamic
   B. Electrodynamic
6. Power amplifiers
   A. Class A single ended
   B. Class B power amp
   C. Push-pull amp
7. Phase inverters
   A. Cascade
   B. Cathode follower
8. Radio frequency amplifiers
   A. Noise figure
   B. Power gain
   C. Cross modulation
9. Intermediate frequency amplifiers
   A. Video amplifiers
   B. Hi-fi amplifiers
      (1) Typical amplifier
      (2) Operation
10. Troubleshooting the hi-fi amplifier and other amps

Task 34: Oscillators

Performance Objective:

With the material provided, the student will demonstrate tank circuit oscillations, and types of oscillators for sinusoidal and nonsinusoidal circuits.

Criterion-Referenced Measure: Eighty percent accuracy must be achieved by student on tests (written, practical) selected by the instructor. He may repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Introduction to oscillators
2. Tank circuit oscillations
3. Types of sinusoidal oscillators
   A. Hartley oscillators
   B. Armstrong oscillators
   C. Colpitts oscillators
   D. Crystal oscillators

4. Types of nonsinusoidal oscillators
   A. Plate coupled multivibrators
   B. Cathode coupled multivibrators
   C. Monostable multivibrators
   D. Bistable multivibrators
5. Use of oscillators

Task 35: Application of Oscillators

Performance Objectives:

Given any schematic, oscillator, voltmeter, ohmmeter, oscilloscope, frequency counter and a standard tool kit, the learner is to, without aid of references:

1. Draw the schematic of the following types of oscillators: Armstrong, Hartley, Colpitts, TPTG, Crystal and Multivibrator.
2. Determine deviation from reference voltages and resistances.
3. Determine if oscillator is functioning.
4. Record voltages, resistances, frequencies and wave shape data.

Criterion-Referenced Measure: The learner is to complete schematic drawings and explanations within two hours to a minimal standard of 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Task 36: Transmitter Circuits

Performance Objective:

With the material provided, the student will show the basic transmitter, buffer amp, transmitter amplifiers, frequency multipliers, and transmitter output.

Criterion-Referenced Measure: The student will be tested to measure his understanding of transmitter theory with written tests, oral drills, and class discussion. He must be able to obtain at least 80 percent accuracy on these tests. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Basic transmitter
2. Block diagram of a typical transmitter
3. Buffer amplifier
4. Frequency multipliers

5. Transmitter amplifiers
   A. Class C
   B. Class A
   C. Class B
6. Transmitter amplifier bias
   A. Fixed bias
   B. Self bias
   C. Cathode bias
7. Transmitter output
8. Transmitter tuning
9. Antenna tuning and coupling
10. Transmitter and antenna tuning procedures
11. Neutralization and parasitic suppression
12. Transmitter keying

Task 37: Modulation Systems

Performance Objective:

With the material provided, the student will illustrate modulation principles, and how they will be used in the transmitter system.

Criterion-Referenced Measure: The student will be tested to measure his ability to at least 80 percent accuracy on modulation systems. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Modulated wave components
2. Amplitude modulation
   A. Power relations and modulation percentage
3. Frequency modulation
   A. Carrier rest
   B. Frequency deviation
   C. Carrier swing
   D. Percent modulation
   E. Modulation index
4. Amplitude modulation circuits
   A. Input circuit modulation
   B. Output circuit modulation
5. Frequency modulation methods

Task 38: Antennas and Transmission Lines

Performance Objective:

With the material provided, the student will illustrate the fundamental principles of antenna theory, and how it will be used in the transmitter system.

Criterion-Referenced Measure: The student will be tested to measure his ability to 80 percent accuracy on the theory of antenna and transmission lines. He may repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Fundamental principles
2. Electric field
3. Magnetic field
4. Basic considerations
5. Electrical length
6. Radiation resistance
7. Input impedance
8. Antenna tuning
9. Polarization and radiation
10. Basic antennas
    A. Marconi antenna
    B. Hertz antenna
11. Transmission lines
12. Characteristic impedance
13. Types of lines
    A. Nonresonant lines
    B. Resonant lines
14. Impedance matching

Task 39: A Typical Transmitter

Performance Objective:

With the material provided, the student will illustrate general circuit description, tuning procedures, and troubleshooting of a typical transmitter.

Criterion-Referenced Measure: The student will be tested on the typical transmitter to measure his application of the theory of transmitters to 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal. He will also be given a troubleshooting test to repair a typical transmitter system. It will be up to the instructor to decide the level he must obtain on troubleshooting.

Performance Guide:

1. Block diagram of a typical transmitter
2. Tuning procedure
3. Troubleshooting the MOPA transmitter

Task 40: Receiver Introduction

Performance Objective:

With the material provided, the student will demonstrate basic receiver theory, and receiver antennas.

Criterion-Referenced Measure: The student will be tested (written, practical) to measure his application of receiver theory to at least 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Receiver considerations
   A. Sensitivity
   B. Signal to noise ratio
   C. Selectivity
   D. Stability
   E. Fidelity
2. Receiver requirements
   A. Antenna
   B. Station selector or tuner
   C. RF amplification
   D. Demodulator or detector
   E. AF amplification
   F. Reproducer
3. Reception
4. Detection
5. Filtering
6. Reproduction
   A. Crystal headphone
   B. Magnetic headphone
7. Receiver antennas
8. Wave traps

Task 41: Receivers

Performance Objectives:

Given a schematic, a superheterodyne receiver, voltmeter, ohmmeter, oscilloscope, signal generator, signal tracer and a standard set of tools, the learner is to:

1. Define wave propagation and basic types of antennas.
2. Identify and differentiate between tuned circuits.
3. Draw a block diagram of any superheterodyne receiver.
4. Record voltages and resistances for all sections using any superheterodyne receiver.
5. Verify alignment of receiver.
6. Make a chart for tube-type receivers showing tube type, function, defects and quality.
7. Localize defect to single section when given a superheterodyne receiver with a malfunction.
8. Replace defective components so that receiver performs to satisfaction of instructor.

Criterion-Referenced Measure: The learner is to complete definitions, identifications and block diagrams within two hours to 80 percent accuracy. He will be allowed to repeat until he achieves personal goal beyond instructor's goal.

Task 42: Business Procedures

Performance Objectives:

Given a service shop environment, a customer, a defective home entertainment unit, methods of financing, display area, service orders and invoices, the learner is to:

1. Greet the customer, advise and converse in a friendly courteous manner.
2. Provide an estimate of repairs using shop format.
3. Complete the following to the satisfaction of the instructor: service order, set identification, invoicing and billing.
4. List the methods of financing available to the customer and the differences between them.
5. Set up a display of home entertainment products.
6. List the advantages and disadvantages of the methods of advertising at the disposal of the service shop.

Criterion-Referenced Measure: The learner is to complete the listings within one hour. Remaining objectives must meet service shop standards. Deficiencies must be corrected for learner to receive credit.

Task 43: Test Instruments

Performance Objectives:

Given safety rules, basic test instruments, signal tracer, frequency counter, post-marker and sweep generator, vectorscope stereo generator, harmonic and distortion analyzer, B & K analyzer, oscilloscope, signal generator and learner perception, the learner is to:

1. Write in outline form the operating instructions for equipment issued and safety precautions and hazards associated with each piece of equipment.
2. List the malfunctions which can be determined with the senses of touch, smell, sight, hearing and taste.

Criterion-Referenced Measure: The learner is to complete outline and listing to satisfaction of instructor. The learner is to operate each piece of equipment in safe and accurate manner to the satisfaction of the instructor. Deficiencies must be corrected to receive credit.

Task 44: Amplifiers

Performance Objectives:

Given safety procedures, test instruments, any home entertainment audio system (stereo amp, tape player, etc.) and a standard tool kit, the learner is to:

1. Outline in writing the safety procedures required to use instruments on system to be repaired.
2. Draw or complete programmed block diagram of system under analysis.
3. Identify types of transducers used.
4. Label and explain function of each control.
5. Discriminate between preamplifiers, voltage amplifiers, current amplifiers and power amplifiers.
6. Write outline of troubleshooting procedure prior to actual troubleshooting.
7. Identify any obvious defect or indication of defect (use senses).
8. Isolate defect to particular section of block diagram.
9. Replace defective components in section.
10. Be thorough so that unit under analysis will function to the satisfaction of instructor.

Criterion-Referenced Measure: The learner must complete outline, drawing, identifications to satisfaction of instructor. Operation of equipment and troubleshooting of system under analysis must be to satisfaction of instructor. Deficiencies must be corrected to receive credit.

Task 45: TRF Receiver Circuits

Performance Objective:

With the material provided, the student will demonstrate TRF receivers and their circuits.

Criterion-Referenced Measure: The student will be tested to measure his application of TRF receiver theory to at least 80 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal. He will also take a performance test to make certain that he can find the trouble on a TRF receiver, and that he can use all the test equipment in the troubleshooting procedures.

Performance Guide:

1. Block diagram of the TRF
2. Ganged tuning
3. Alignment
4. Trimmers
5. Hetrodyne action
6. Heterodyne detection
7. Beat frequency oscillator
8. Frequency measurement
9. Audio frequency detection
10. Electron tube detection
    A. Diode detection
    B. Grid leak detection
    C. Plate detector
11. Controls
12. Troubleshooting the TRF receiver

Task 46: Superheterodyne Receivers

Performance Objective:

Given safety procedures, test instruments, an AM/FM, AM or FM superheterodyne receiver and a standard tool kit, the learner must:

1. Identify available technical data, draw a block diagram of the receiver and identify all controls and their function.
2. Explain how each section of the receiver works.
3. Write an analysis in outline form indicating troubleshooting procedure.
4. Identify any obvious defect or indication of defect (use senses).
5. Isolate defect to single section of block diagram.
6. Replace defective component(s).
7. Be thorough so that unit under analysis will function to the satisfaction of instructor.

Criterion-Referenced Measure: The learner must complete outline, drawings, identifications to satisfaction of instructor. Operation of equipment and troubleshooting of unit under analysis must be to satisfaction of instructor. Deficiencies must be corrected to receive credit.

JOB OPPORTUNITIES AFTER COMPLETION OF PHASE TWO BASIC ELECTRONICS FOR HIGH SCHOOL STUDENTS

RADIO REPAIRMAN

Job Description:

Troubleshooter, radio repairs, radio receivers, phonographs, recorders and other electronic audio equipment. Uses circuit diagrams, test wiring, tubes, resistors and other parts, electronic test equipment, such as voltmeters and oscilloscopes to locate defects and replace defective parts. Using handtools, solders loose connections with soldering iron. Computes charges for labor and materials. May be designated according to type of radio repaired as automobile radioman, radio repairman, domestic.

Task 47: Monochrome TV Receivers

Performance Objectives:

Given safety procedures, test instruments, monochrome TV receivers, and a standard tool kit, the learner must:

1. Identify available technical data, draw a block diagram, or use block diagram format, identify tube used in each section and identify all controls and their functions.
2. Explain how each section of the receiver works.
3. Write in outline form an analysis indicating troubleshooting procedure prior to actual repair.
4. Identify any obvious defect or indication of defect (use senses).
5. Isolate defect to single section of block diagram.
6. Replace defective component(s).
7. Be thorough so that unit under analysis must function to satisfaction of instructor.

Criterion-Referenced Measure: The learner must complete outline, drawings, and identifications to satisfaction of instructor. Operation of equipment and troubleshooting of unit under analysis must be to satisfaction of instructor. Deficiencies must be corrected to receive credit.

Task 48: The Television System

Performance Objective:

With the material provided, the student must demonstrate the television system.

Criterion-Referenced Measure: The student will be tested to make sure that he can outline, to at least 85 percent accuracy, the basic TV system. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Picture elements
2. Transmitting and receiving picture information
3. Scanning
4. Motion pictures
5. Frame and field frequencies
6. Vertical and horizontal frequencies
7. Synchronization
8. Picture qualities
9. Television channels
10. The associated FM sound signal
11. Color television
12. Standards of transmission

Task 49: TV Receivers

Performance Objectives:

With the material provided, the student must:

1. Demonstrate basic block diagrams of TV receivers.
2. Illustrate how to isolate trouble in a TV receiver to a specific block in the receiver.

Criterion-Referenced Measure: The student will be required to localize a trouble on a black and white TV. He must obtain 100 percent accuracy if he is to go any further in this phase of his training.

Performance Guide:

1. Receiver block diagrams
2. Receiver circuits
3. Sound take-off
4. Functions of the receiver circuits
5. Receiver operating controls
6. Localizing troubles to a receiver section
7. Multiple troubles
8. Monitor receivers

Task 50: TV Power Supply

Performance Objective:

With the material provided, the student will demonstrate TV power supplies and how to repair them.

Criterion-Referenced Measure: The student will be tested to measure his analysis of the TV power supply and how to troubleshoot them. He must obtain at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Full wave rectifier
2. DC voltage polarities
3. Heater circuits
4. Voltage doublers
5. Transformerless low voltage power supply
6. Stacked low voltage circuits
7. High voltage supplies
8. High voltage safety precautions

9. High voltage troubles
10. Trouble in the low voltage supply
11. Hum in the low voltage supply
12. Troubleshooting

Task 51: Composite Video Signal

Performance Objective:

With the material provided, the student will illustrate what the composite video signal contains and how it is used in the TV system.

Criterion-Referenced Measure: The student will be tested (written, practical) to measure his progress to at least 85 percent on the material covered in the composite video signal. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Construction of the composite video signal
2. Picture information and the video signal
3. Video frequency and picture information
4. Maximum number of picture elements
5. Test patterns
6. DC components of the video signal
7. GAMA

Task 52: Picture Tubes (cathode ray tubes)

Performance Objective:

With the material provided, the student will illustrate the different types of picture tubes used in the modern black and white TV receivers in use today.

Criterion-Referenced Measure: The student will be tested to measure his application of the theory of picture tubes, their operation and safety precautions. He must achieve at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Deflection, focusing, and centering
2. The luminescent screen
3. Types of tubes
4. The electron beam

5. Focusing the electron beam
   A. Electrostatic
   B. Magnetic
6. Picture tube precautions
7. Picture tube troubles

Task 53: The RF Tuner

Performance Objective:

With the material provided, the student will illustrate how the RF tuner functions and its place in the TV system.

Criterion-Referenced Measure: The student will be tested to measure his application to at least 85 percent accuracy on the operation and use of the RF tuner. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Operation of the RF tuner
2. The RF amplifier stage
3. RF amplifier circuits
4. The mixer stage
5. The local oscillator
6. RF alignment
7. Conversion methods for UHF channels
8. Types of RF tuner circuits
9. UHF tuner circuits
10. Wireless remote control
11. Receiver noise
12. Troubles in RF tuners (VHF and UHF)

Task 54: Picture IF Amplifier

Performance Objective:

With the material provided, the student will demonstrate the picture IF and its circuits and place in the TV system.

Criterion-Referenced Measure: The student will be tested to measure his analysis of IF amplifiers operation, how to troubleshoot them and their roll in the TV system. The student must achieve 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Picture IF response
2. The intermediate frequency
3. IF amplification
4. Double-tuned IF amplifiers
5. Single-tuned IF amplifiers
6. Stagger-tuned IF amplifiers
7. Wave traps
8. Picture IF amplifiers
9. Solid state IF amplifiers
10. Troubles in the IF stages

Task 55: Video Detector

Performance Objective:

With the material provided, the student will illustrate the video detector, its operation, how to repair video detector troubles, and how it will be used in the TV system.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair detector circuits and his analysis of the theory of detector circuits. He must achieve 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Detection
2. Detector polarity
3. Video detector and load resistance
4. Video detector filter
5. Detector diodes
6. Video detector circuits
7. Functions of the composite video signal
8. Detecting the 4.5 MC intercarrier signal
9. Troubles in the detector

Task 56: Video Amplification

Performance Objective:

With the material provided, the student will demonstrate video amplification, repairs, operation, and how they are used in the TV system.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair troubles in the video amplifier circuits, and his analysis of the operation of video amplifiers.

Performance Guide:

1. The video signal and picture information
2. Polarity of the video signal
3. Amplification of the video signal
4. Manual contrast control
5. Video frequencies
6. Frequency distortion
7. Phase distortion
8. Frequency response of the video amplifier
9. Video amplifier circuits
10. Solid state video amplifier circuits
11. Troubles in the video amplifier

Task 57: Automatic Gain Control

Performance Objective:

With the material provided, the student will illustrate automatic gain control circuit operation, and how to repair defective circuits.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair AGC circuits, their operation, and how they are used in the TV system. He must achieve at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. How the AGC bias control gain
2. Advantages of AGC for picture signal
3. AGC circuits for picture signal
4. Keyed AGC circuit
5. AGC level adjustment
6. AGC troubles

Task 58: Sync Separation

Performance Objective:

With the material provided, the student will illustrate sync separation circuits, and how to repair defective circuits.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair sync troubles, and his analysis of sync circuits to at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Vertical synchronization of the picture
2. Horizontal synchronization of the picture
3. Separation of the sync from the video signal
4. Integration of the vertical sync
5. Noise in the sync
6. Sync circuits
7. Sync and blanking bars on the screen
8. Troubles in the sync

Task 59: Vertical Deflection Circuits

Performance Objectives:

With the material provided, the student will illustrate vertical deflection circuits, and how to repair defective circuits.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair defective vertical deflection circuits, and his analysis of the theory to at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Triode vertical output stage
2. Vertical output transformers
3. Vertical linearity
4. Internal vertical blanking
5. Vertical deflection circuit with blocking oscillator
6. Combined vertical osc and output circuit
7. Solid state vertical deflection circuits
8. Vertical deflection troubles

Task 60: Horizontal Deflection Circuits

Performance Objective:

With the material provided, the student will illustrate how to repair horizontal deflection of circuits, and how they are used in the TV system.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair defective horizontal circuits, and his analysis of the circuits to at least 85 percent. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Functions of the horizontal output stage
2. Horizontal amplifier stage
3. Damping in the horizontal output circuit
4. Horizontal scanning and damping
5. Boosted B voltage
6. Flyback high voltage
7. Horizontal deflection circuits
8. Deflection yokes
9. Solid state horizontal deflection circuits
10. Troubles in the horizontal deflection circuits

Task 61: Horizontal AFC Circuits

Performance Objective:

With the material provided, the student will illustrate how to repair, and how the horizontal AFC is used in the TV system.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair AFC circuits, and analyze the operation of the circuits. He must achieve at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. AFC requirements
2. Push-pull discriminator
3. Circuit of multivibrator controlled by sync discriminator
4. Single ended sync discriminator
5. DC control tube
6. Sine wave oscillator with reactance tube
7. Hold-in range and pull-in range
8. Filtering the DC control voltage
9. Phasing between horizontal blanking and flyback
10. Troubles in the AFC

Task 62: The FM Sound System

Performance Objectives:

With the material provided, the student will:

1. Illustrate the FM sound system employed in the TV system.
2. Analyze the theory and how to repair defective sound circuits.

Criterion-Referenced Measure: The student will be tested to measure his analysis of and ability to repair defective sound circuits. He must achieve 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Definition of FM terms
2. Reactance tube modulator
3. Advantages of FM
4. Pre-emphasis and de-emphasis
5. Receiver requirements for and FM signal
6. Complete sound IF circuit
7. Detection of the FM signal
8. The limiter
9. Complete sound circuit
10. Troubles in the sound circuit

Task 63: Receiver Servicing

Performance Objective:

With the material provided, the student will demonstrate how to service the complete black and white TV receiver.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair defective TV receivers. He must achieve 100 percent accuracy. This will be determined by the instructor.

Performance Guide:

1. Receiver adjustments
2. Types of ghost
3. External interference in the picture
4. Sound in the picture
5. Localizing hum troubles
6. Signal injection
7. Use of the TV analysis
8. Localizing receiver troubles

9. Oscilloscope measurements
10. Alignment precautions
11. Typical receiver circuit

Task 64: Introduction to Color Television Receivers

Performance Objectives:

Given safety procedures, test instruments, color TV receiver and a standard tool kit, the learner must:

1. Identify available technical data, draw or use block diagram format, identify tube used in each section and identify all controls and their function.
2. Outline differences between monochrome and color TV receivers.
3. Write in outline form an analysis indicating troubleshooting procedure prior to actual repair.
4. Identify any obvious defect or indication of defect (use senses).
5. Isolate defect to single section of block diagram.
6. Replace defective component(s).
7. Converge color receiver.
8. Be thorough so that unit under analysis will function to the satisfaction of the instructor.

Criterion-Referenced Measure: The learner must complete outline, drawings, identifications to satisfaction of instructor. Operation of equipment and troubleshooting of unit under analysis must be to satisfaction of instructor. Deficiencies must be corrected to receive credit.

Task 65: The Color TV System

Performance Objective:

With the material provided, the student will illustrate the theory of color TV.

Criterion-Referenced Measure: The student will be tested on the theory of color TV. He must achieve at least 85 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Color signals
2. Color addition
3. Definition of color terms
4. Color television broadcasting
5. Y signal
6. Types of color video signals
7. Q signal

8. I signal
9. R-Y signal
10. B-Y signal
11. G-Y signal
12. Desaturated chrominance signal
13. Matrix circuits
14. Color subcarrier frequency
15. Color synchronization
16. Colorplexed composite video signal waveforms
17. Vector addition of color signals

Task 66: Color Television Receivers

Performance Objective:

With the material provided, the student will demonstrate how to repair defective color TV receivers.

Criterion-Referenced Measure: The student will be tested to measure his ability to repair defective color TV receivers, and how the color circuits work. He must achieve 95 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Chrominance section
2. Chrominance amplifier circuits
3. Burst amplifier
4. Color AFC circuits
5. Automatic color control (ACC) bias
6. Color killer circuit
7. Color demodulator circuit
8. Color CRT'S
9. Set up adjustment
10. Convergence procedure
11. Schematic of color section of receiver
12. Color troubles

Task 67: Antennas and Transmission Lines

Performance Objective:

With the material provided, the student will demonstrate the theory of TV antennas, and how to install them in the correct manner.

Criterion-Referenced Measure: The student will be tested to measure his ability to install and repair antenna systems. He must achieve 95 percent accuracy. He is allowed to repeat until he achieves personal goal beyond instructor's goal.

Performance Guide:

1. Resonant lines of an antenna
2. Definition of antenna terms
3. Ghost
4. Straight dipole
5. Folded dipole
6. Broadband dipoles
7. Long wire antennas
8. Parasitic Arrays
9. Multiband antennas
10. Stacked arrays
11. Transmission lines
12. Impedance matching
13. Antenna installations
14. Troubles in the antenna system

TELEVISION SERVICE AND REPAIRMAN

Television and radio repairman; television repairman. Repairs and adjusts radios and television receivers; tunes receivers on all channels and observes audio and video characteristics to locate source of trouble. Adjusts controls to obtain desired density, linearity, focus, and size of picture. Examines chassis for defects. Test voltages and resistance of circuits to isolate defect following schematic diagram and using voltmeter, oscilloscope, signal generator, and other electronic testing instruments. Test and changes tubes, and solid state devices. Solders loose connections and repairs or replaces defective parts using hand tools and soldering iron. Repairs radios and other audio equipment. May install television sets, and antenna systems.

ELECTRONIC TECHNOLOGY

POST-SECONDARY CURRICULUM

ELECTRONIC TECHNOLOGY

A Two-Year Post High School Curriculum

Introduction

PHENOMENAL technological advances have been accomplished by scientists, engineers, mathematicians, and technicians working together as a team in developing new applications for scientific laws. Ever-increasing need for the combined talents of such teams have resulted in an unprecedented demand, not only for the creative scientists and engineers, but also for the technically competent supporting personnel and skilled craftsmen with a thorough working knowledge of the basic principles of mathematics and science. This group of supporting technicians and skilled craftsmen is making an increasingly greater contribution to the technical team, and is in critical demand wherever there is work in product development of a scientific or technical nature.

The post-secondary phase of the performance-based curriculum in Electronics was developed by an instructor at Sowela Technical Institute. It has been written to give interested people information concerning a type of full-time two-year program which can provide certain technical education for entry into jobs in the field of electronics in support of engineers and scientific personnel.

This course offers such subjects as Mathematics, English, Physics, Technical Writing, Speech and Developmental Reading. The technical courses begin in the first quarter, but they are accelerated in the third through eighth quarter to include Communications, Instrumentation, and Computers.

The Electronics Technology Curriculum and the course outline should be of assistance to high school counselors in providing information in this particular field to interested students.

The courses outlined in this curriculum have been arranged to provide specialized instruction in a two-year post high school electronics program. The curriculum is organized to provide basic and technical preparation for jobs in a variety of occupations in the field of electronics. The courses are arranged in workable sequence suitable to the instructional needs of students with an appropriate balance between a technical course, general education courses, and laboratory applications. This is not a pre-engineering curriculum.

A graduate of this program will have a good foundation in the field of electronics and considerable experience with the "hardware" encountered in the electronics industry.

To be successful in this program, a person must be a high school graduate with a good background in mathematics or be capable of learning mathematics if job pre-training in this field is limited.

Graduates from this two-year curriculum will be capable of performing technical assignments on jobs in the field of electronics. Most industries expect these graduates to continue training in industry as they gain experience on the job. Such special training programs are common throughout the electronics industry and usually provide excellent opportunities for advancement.

Employment prospects are very promising. Electronic technicians are in great demand and short supply. These are the reasons:

1. Electronic technicians take over many tasks engineers have been doing, releasing engineers for more scientific levels of work.
2. Advances in scientific knowledge have created a need for more people educated in all areas of science, engineering and technology.
3. Increased research and development require that each engineer or scientist be assisted by at least one, and often several, electronic technicians.

4. Development and industrial use of nuclear power has opened a new area of employment.

5. Automation requires more and better educated people to design, manufacture, install, and maintain complex equipment.

These factors point to a bright future for electronic technicians in business and industry and government services. Starting salaries are comparatively favorable--beginning Engineers, i.e. 1970-75, $600-$750 a month.

Careful coordination of laboratory and lecture is accomplished in order that the instructional objectives may be realized. Much of the theory is re-emphasized in the laboratory in order to accomplish this end.

About the Curriculum

EXTENSIVE planning is given to the arrangement and emphasis on subject matter included in this curriculum. As each new concept or area of knowledge is formally presented, it is given practical application of increasing depth as the concept is built upon by each succeeding technical course in the curriculum. Once introduced a concept is never dropped, but rather it is extended and applied in correlation with each new concept introduced in subsequent courses.

By devoting a major part of the laboratory time in the circuit courses to mathematical analysis, a highly effective integration is achieved. With the additional outside study requirement, the mathematic needs of the student as related to Electronics are provided.

The first two quarters of the curriculum outlined here will provide a solid base of knowledge on which to build the advanced course instruction. The subsequent study is circuit-based rather than equipment-based, requiring a continuation and extension of mathematical analysis, including a significant amount of "handbook" design. When complex electrical and electronics

equipment is utilized for instruction, those special circuit applications that make the equipment unique are studied separately. This then becomes the heart of the study program--broad applications of basic principles well learned through practical analysis and reinforced through application to specific equipment.

The curriculum can only suggest those areas of information which should be covered to give students scientific knowledge which will enable them to perform at a level of competency in positions in industry.

Although "safety" is not designated as a special subject matter area in the outline of courses, it is an indispensable part of each learning experience. Laboratory exercises stress the accident potential of each learning experience and the preventative measures to be taken to protect against possible injury. Safety is directly related to the manner in which a person performs, functions, or exposes himself to possible injury and the attitude he has toward the objects or materials with which he works. It is almost impossible to "teach" good safety. Safety is a part of a way of life. Proper safety practices will grow out of desirable personal values, attitudes, and procedures in the use of materials or objects. A student is taught to perform each function of his job safely.

Too much emphasis cannot be placed upon the need for technically trained people to be able to communicate data and ideas clearly and effectively. Basic courses in communication are taught in the curriculum to give students refresher work as well as exercises in functional English. As with mathematics and science concepts, there is practical application of proper usage of English in all courses. All laboratory reports and written assignments are corrected for grammar and for proper writing and reporting procedures.

ELECTRONIC TECHNOLOGY PROGRAM SCHEDULE

FIRST YEAR

COURSE TITLE	SUGGESTED HOURS
First Quarter	
Basic Electricity	300
Math (Algebra & Slide Rule)	60
Second Quarter	
Basic Electronics	240
Math (Trigonometry)	60
English (Grammar)	60
Third Quarter	
Physics	120
Transistors I	120
Closed Circuit T.V.	120
Fourth Quarter	
English (Reports & Speech)	60
Transistors II	120
Test Equipment	60
Lab Projects	120

SECOND YEAR

Fifth Quarter	
Industrial Electronics I	120
Instrumentation I	120
Circuit Analysis	120
Sixth Quarter	
Industrial Electronics II	120
Instrumentation II	120
Programming (Fortran IV)	120
Seventh Quarter	
Switching Circuits	120
Communications I	120
Microwave	120
Eighth Quarter	
Digital Machine Design	120
Communications II	120
Term Project	120

OVERALL COURSE OBJECTIVE FOR ELECTRONIC TECHNOLOGY

Performance Objective:

Obtain all the basic skills and information required by industry in computers, communications and instrumentation to obtain an entry level job.

Criterion-Referenced Measure:

Performance to 75 percent accuracy or better for each of the required courses as specified in the electronics technology curriculum.

COURSE OUTLINE

FIRST YEAR - FIRST QUARTER

Task 1: Basic Electricity

Performance Objective:

Introductory material in basic direct and alternating current circuits will be used to supply solutions to basic problems. Difficulty level will start with a nonelectronic based knowledge and go up to but will not include the more advanced network theorems such as Norton, Thevenin, Loop/Nodal, etc.

Criterion-Referenced Measure:

Performance as measured by testing on both unit and final written test to a 75 percent level or higher, and instructor evaluations of formal written lab reports which show a thorough understanding of class related reinforcing experiments.

Description:

This course is designed to introduce the beginning student to the fundamental concepts of electricity and electronics. The approach used to teach the theoretical ideas of the course is one of programmed instruction where the student is allowed sufficient freedom in his/her advancement through the subject matter. Supplemental tests, as well as a readily available instructor, are used as needed. As a complement to the theoretical knowledge, laboratory work is an integral portion of the course. Experiments are designed so that they relate directly to the material being studied in the text. The student is tested frequently to ascertain what progress has been made, as well as to identify any areas in which he/she may be having difficulty.

The course is designed to take the average student approximately two quarters to complete the required work.

THEORY

Direct Current Fundamentals

		Hrs.
I.	Atomic Structure and Static Electricity	6
II.	Characteristics of Current, Voltage, and Resistance	6
III.	Relationships of Current, Voltage, and Resistance	6
IV.	The Series Circuit	6
V.	The Parallel Circuit	6
VI.	The Series-Parallel Circuit	6
VII.	The Voltage Divider	6
VIII.	Magnetism	6
IX.	Electromagnetic Induction	6
X.	Basic Meter Movements	6

Alternating Current Fundamentals

I.	Introduction to AC	6
II.	Introduction to Inductance	6
III.	Introduction to Capacitance	6
IV.	Transformer Action	6
V.	AC Power	6
VI.	AC Resistive Circuits	6
VII.	RL Reactive Circuits	6
VIII.	RC Reactive Circuits	6
IX.	RLC Reactive Circuits	6
X.	Tuned Circuits	6
	TOTAL	120

LABORATORY

1.	Electronic Components and Symbols	9
2.	Reading Schematic Diagrams	9
3.	Introduction to the VTVM	9
4.	Resistor Color Codes	9
5.	DC Voltage Measurements	9
6.	DC Current	9
7.	OHM's Law	9
8.	The Series Circuit	9
9.	The Parallel Circuit	9
10.	The Series-Parallel Circuit	9
11.	Characteristics of Meter Movements	9
12.	Multipliers for Voltmeters	9
13.	Use of the Oscilloscope	9
14.	Characteristics of Inductors	9
15.	Characteristics of Capacitors	9
16.	The Power Transformer	9
17.	Series RL Impedance	9
18.	RC Time Constants	9
19.	Series Resonance	9
20.	Parallel Resonance	9
	TOTAL	180

TOTAL THEORY AND LABORATORY 300

Task 2: Algebra and Slide Rule

Performance Objective:

General Algebra theory will be used to obtain solutions to related electronic problems. Solution techniques will include factoring, fractions, exponents, linear and quadratic equations, equation systems and the use of determinants in their solution. A slide rule will be used to obtain all required table constants as well as a simplification tool to reduce iteration work load.

Criterion-Referenced Measure:

A sample of electronic-related problems that will cover each of the math study areas will be used to test for performance level. A grade of 75 percent or higher will be required for successful completion. All table information will be obtained from a slide rule and the test length will be sufficiently long to require a slide rule for completion within the alloted time.

Description:

A general algebra course including a review of the development of the real number system, and the fundamental operations. Areas of study include: factoring, fractions, exponents, linear equations, quadratic equations, systems of equations, and use of determinants and logarithms.

Instruction is also given in how to use a Slide Rule.

Performance Guide: THEORY

		Suggested Hours
I.	The Number System	5
II.	Scientific Notation	4
	A. Significant Figures	
	B. Addition and Subtraction	
	C. Multiplication and Division	
	D. Estimation of Results	
III.	Fractions	4
	A. Definitions and Fundamental Principles	
	B. Addition of Fractions	
	C. Multiplication of Fractions	
	D. Division of Fractions	
IV.	Special Products and Factoring	11
	A. Product of Binomials	
	B. Product of Polynomials	
	C. Factoring Trinomials	
	D. Factoring Binomials	
	E. Factoring by Grouping	
V.	Exponents and Radicals	4
	A. Positive and Negative Exponents	
	B. Roots of Numbers	
	C. Product and Quotient of Radicals	

VI.	Linear and Fractional Equations	4
	A. Definitions	
	B. Linear Equations in one unknown	
	C. Solving Stated Problems	
VII.	Quadratic Equations	5
	A. Definitions	
	B. Solution by Factoring	
	C. Solution by Completing the Square	
	D. The Quadratic Formula	
	E. Problems that lead to Quadratic Equations	
VIII.	Functions and Graphs	3
	A. Functions	
	B. The Graph of a Function	
IX.	Systems of Equations	10
	A. Equations in two variables	
	B. Graphical Solution of a System of Equations	
	C. Algebraic Methods - Eliminations	
	D. Problems leading to Systems of Equations	
X.	Elementary Determinants of the Second Order	5
	A. Determinants of the Second Order	
	B. Determinants of the Third Order	
XI.	Logarithms	5
	A. Definitions	
	B. Common, or Briggs' Logarithms	
	C. Use of Log Tables	
	D. Slide Rule	
	TOTAL HOURS	60

COURSE OUTLINE

FIRST YEAR - SECOND QUARTER

Task 3: Basic Electronics

Performance Objective:

Introductory material in basic electronics to include active devices such as diodes, triodes and amplifier circuits will be used to build and understand the operating principles of such basic circuits as audio and R.F. amplification, oscillators, modulation and detection.

Criterion-Referenced Measure:

Successful completion of written test covering required material to a performance level of 75 percent is necessary. All required circuits will be built, all troubles removed, made to operate to lab specifications, and a formal report will be required for each experiment.

Description:

This course is a continuation of Basic Electricity. The intent of the course is to add to those underlying basic principles presented earlier. In such a manner as to give the student a comprehensive idea about basic

electricity/electronics. As the electronics subject matter becomes more complex, so does the tool of mathematics, which is being taught concurrently.

Performance Guide:

THEORY

		Suggested Hours
I.	Diode Tubes	7
II.	Circuit Abbreviations	6
III.	Triode Tubes	7
IV.	Triode Amplification	7
V.	Tetrode Tubes	7
VI.	Pentode Tubes	7
VII.	Introduction to Power Tubes	7
VIII.	Use of Power Tubes	7
IX.	Classes of Amplification	7
X.	Amplifier Coupling & Controls	7
XI.	Audio Amplification	7
XII.	Wideband Amplification	7
XIII.	RF Amplification	7
XIV.	Impedance Matching in Amplifiers	7
XV.	Oscillator Principles	7
XVI.	The LC Oscillator	7
XVII.	The Crystal Oscillator	7
XVIII.	Fundamentals of Modulation	7
XIX.	Fundamentals of Detection	7
XX.	Fundamentals of Superheterodyning	7
XXI.	Analysis of the Superheterodyne Stage	7
XXII.	Introduction to Power Supplies	7
XXIII.	The Total Superheterodyne Receiver	7
	TOTAL HOURS	160

LABORATORY

1.	Diode Characteristics	10
2.	Triode Characteristics	10
3.	The Triode Amplifier	10
4.	Tube Type Power Amplifier	10
5.	Push-Pull Power Amplifier	10
6.	Defect Analysis in Amplifiers	10
7.	Half & Full Wave Rectification	10
8.	Power Supply & Filter	10
		80
	TOTAL HOURS	240

Task 4: Trigonometry

Performance Objectives and Criterion-Referenced Measures:

1. Under verbal and written testing (75%), the student will be able: to state the definitions of sine, cosine, and tangent; to solve any right triangle; to linearly interpolate from a table of trigonometric

functions; to read values of the functions for angles larger than 90 degrees as signed numbers; to use the laws of sines and cosines in solving triangles that are not right triangles.

2. Under verbal and written testing (75%), the student will be able: to add and subtract vectors in a plane; to convert from polar to rectangular and from rectangular to polar form; to graphically add and subtract vectors in a plane; and to resolve a vector into components in specified directions.

Description:

Introduction to the trigonometric functions: use of the trigonometric functions in solving triangles and vectors. Use of fundamental identities; radian measure; logarithms; and polar coordinates.

Performance Guide: THEORY

		Suggested Hours
I.	The Trigonometric Functions	5
	A. The Number System and Basic Definitions	
	B. Definitions of the Trigonometric Functions	
	C. Values of the Trigonometric Functions	
II.	Solution of Right Triangles	15
	A. Use of Trigonometric Tables	
	B. Trigonometric Tables	
	C. Vectors	
III.	Fundamental Identities	10
	A. Fundamental Identities	
	B. Trigonometric Reduction	
	C. Identities	
IV.	Radian Measure and Functions of Numbers	
V.	Graphs of the Trigonometric Functions	10
	A. Introduction	
	B. Bounds and Amplitude	
	C. Graphs of the Trigonometric Functions	
VI.	Logarithms	10
	A. Definition	
	B. The Common, or Briggs System of Logarithms	
	C. Logarithms Computations	
VII.	Polar Coordinates	10
	A. Definitions and Concepts	
	B. Construction of the Graph	
	C. Relations between Rectangular and Polar Coordinates	
	TOTAL HOURS	60

Task 5: Supplemental Basic Information

Performance Objective:

Obtain a basic working knowledge of solid state theory and circuits through study and laboratory experience.

Criterion-Referenced Measure:

Understanding of theory will be measured by objective testing with successful completion being a grade of 75 percent or higher. Laboratory experiments will be pursued until satisfactory circuit operation is obtained as specified in the laboratory experiment or exercise and each will be followed by a technical report which re-emphasizes a thorough understanding of the information presented.

Performance Guide:

Should a student be above average in his/her achievement and complete the preceding requirements in less than the two quarter allotment, he/she will be allowed to spend the remaining time in the quarter pursuing the following subject matter.

THEORY

I. Introduction to Semiconductors
II. Introduction to Transistors
III. Transistor Parameters
IV. Parameter Calculations
V. Bias Stabilization
VI. Load Line Calculations
VII. Introduction to Audio Amplification
VIII. Audio Output Circuitry
IX. Tuned Amplification
X. Wideband
XI. LC Oscillator Principles
XII. Methods of Transistor Construction
XIII. Transistor Specifications

LABORATORY

1. Half-wave Rectification
2. Physical Characteristics of Transistors
3. Transistor Testing
4. Determination of Alpha & Beta
5. Transistor Data & Interpretation
6. Transistor Audio Amplifier
7. Common Emitter Amplifier
8. Cascaded Amplifier
9. Frequency Response of Audio Amplifiers
10. Push-pull Power Amplifier
11. Analysis of the Total Amplifier
12. The TRF Receiver
13. The Hartley Oscillator

Task 6: Composition & Rhetoric

Performance Objectives:

To be able to identify parts of speech as found in sentences and recognize sentence patterns in common use. To be able to use a dictionary to determine proper spelling, meaning and pronunciation. To be able to write a sentence given in one pattern as an equivalent sentence in another pattern.

Criterion-Referenced Measure:

A grade of 75 percent or higher on a verbal and written examination will be required for successful completion.

Description:

This course is intended to teach the student the basic skills of English, the principles of correct word usage, proper punctuation and capitalization, effective communication skills through various types of business letters, telegrams, memorandums, and technical reports, and spelling words of a general and electronic nature.

Performance Guide:

THEORY

		Suggested Hours
I.	Basic Principles of Grammar	20
	A. Eight principal parts of speech, and usage	
	B. Troublesome problems	
II.	Basic Principles of Punctuation and Capitalization	14
	A. Types of punctuation marks and usage.	
	B. Open and closing punctuation in letter writing	
	C. Correct way of writing numbers	
	D. Standard rules for capitalization	
III.	Basic Principles of Underlying Construction and Composition of Business Letters, Telegrams, Memorandums, and Business Reports	12
	A. Organization of materials and ideas for different types of business letters	
	B. Proper procedure used in writing business letters	
	C. Proper procedure for writing telegrams	
	D. Basic fundamentals for writing memorandums and business reports	
IV.	Basic Spelling Words--General and Electronic Terminology	14
	A. Correct spelling and usage of words	
	B. Correct pronunciation of words	
	C. Proper way to use dictionary, and consultation of such when in doubt of spelling, pronunciation, or definition	
	TOTAL HOURS	60

COURSE OUTLINE

FIRST YEAR - THIRD QUARTER

Task 7: Physics

Performance Objectives:

To learn and be able to add, subtract, multiply, divide, round, and estimate the result of calculations in scientific notation, to convert a measurement with one set of units to an equivalent one with other units, to represent forces with vectors, to resolve vectors into components, to find the resultant of concurrent forces, find the equilibrant force, solve problems requiring torques for their solution, calculate vector momenta, compute velocity from conservation of momenta, compute motion with uniform acceleration, to relate force/change of momentum and force/acceleration by using Newton's Laws, to calculate gravitational attraction and acceleration, to figure kinetic and potential energy of a particle, and other basic physical phenomenon.

Criterion-Referenced Measure:

Achieve a level of 75 percent or higher on written examination. A laboratory manual is required with each assigned experiment written in the appropriate technical form.

Description:

Introduction to basic principles of science. Precision measurements, laws of motion, machines, optics, wave motion and electromagnetism are presented in relation to the demands of industry.

Performance Guide:

THEORY

		Suggested Hours
I.	Mechanics	15
II.	Heat Transfer	15
III.	Wave Motion	15
IV.	Optics	13
V.	Electromagnetism	21
VI.	Atomic Physics	2
		81

TOTAL HOURS

LABORATORY

1.	Measurements	3
2.	Heat Transfer	3
3.	Acceleration of Gravity	3
4.	Projectile Motion	3
5.	Newton's Second Law	3
6.	Coefficient of Friction	3

7.	Simple Machines	3
8.	Speed of Sound	3
9.	The Sonometer	3
10.	Orating Spectrometer	3
11.	Index of Refraction	3
12.	Thin Lens	3
13.	Polarized Electromagneti: Radiation	3
14.	Magnetic Fields	3
15.	Electromagnetic Induction	3
		52
	TOTAL HOURS	126

Task 8: Transistors I

Performance Objective:

Given a set of transistor specifications, semiconductor theory and device operating, parameters will be applied to compute component sizes, circuit parameters, and circuit limits including device makeup such as germanium or silicon and device problems such as I_{CBO}, BETA, and V_{BE}.

Criterion-Referenced Measure:

Successful construction of stable circuits to deal with each of the problems of the solid-state circuits presented in this block of theory will be required. Laboratory equipment will be used to measure circuit integrity for variation parameter and each experiment will be followed by a report of results obtained. All theory tests will require a grade of 75 percent correct/completion for success.

Description:

Course is designed to teach the student the theory of operation of semiconductor devices. Course includes a study of the makeup of silicon and germanium devices, as well as a detailed study of the circuits in which transistors are to be found. Student learns to compute component sizes, circuit parameters, and circuit limits.

Performance Guide: THEORY

		Suggested Hours
I.	Semiconductor Physics	6
II.	The P-N Junction	8
III.	A. Rectifying Properties of a P-N Junction	
	B. The I-V Characteristics of a Semiconductor Diode	
III.	Large Signal Diode Approximations	8
	A. The Ideal Diode	
	B. The Second Approximation of a Real Diode	
	C. The Third Approximation of a Real Diode	
	D. Reverse Current	
	E. The Zener Diode	

IV.	Small Signal Diode Approximations	10
	A. Superposition	
	B. Diode Capacitance in the Reverse Region	
V.	Common Base Approximations	10
	A. The I-V Characteristics of the Common Emitter Connection	
	B. The Beta of a Transistor	
	C. Base Bias	
	D. Emitter Bias	
	E. The Voltage Gain of an Emitter Biased Stage	
	F. Effects of Source Resistance	
VI.	Common Collector Approximations	8
	A. Derivation of CC Formula	
	B. Gain and Input Resistance	
	C. The Darlington Pair	
VII.	Large Signal Operation	10
	A. The DC Load Line	
	B. The AC Load Line	
	C. Obtaining Maximum Unclipped Signal	
	D. Load Lines for the CE Connection	
	E. Load Lines for the CC Connection	
VIII.	Bias Arrangements	10
	A. Beta Sensitivity	
	B. Base Bias	
	C. Base Bias with Feedback	
	D. Emitter Bias	
		70

LABORATORY

1.	The Diode Rectifier	2
2.	The Zener Diode	4
3.	The Common Base Amplifier	4
4.	The Common Emitter Amplifier	10
5.	The Common Collector Amplifier	8
6.	The Darlington Pair	6
7.	Emitter Biased Amplifier (Beta Sensitivity)	6
		40
	TOTAL HOURS	110

Task 9: Closed Circuit T.V.

Performance Objective:

Be able to set up, tune, locate internal troubles, build and maintain routine maintenance schedules for closed circuit T.V. systems. Understand the operation of and be able to select the correct camera types, lense systems, and lighting components.

Criterion-Referenced Measure:

Make all adjustments necessary on an actual television system to set up correct operation. Given a system with internal troubles, locate the problem, repair the faulty circuit and return the system to service. A grade of 75 percent or higher must be maintained on all examinations.

Description:

This course is designed to give a student a fundamental background in closed circuit T.V. systems. Primarily solid state vidicon camera types are presented from both installation and maintenance aspects. Camera types, lighting requirements, lens systems, and environmental considerations are discussed. It should be fully understood that this course does not prepare a student for a state television repair license or a job in that skill area, as only industrial and instrumentation camera/monitor systems are presented.

Performance Guide:

THEORY

		Suggested Hours
I.	Introduction	10
	A. Systems	
	B. Environments	
II.	Cathode Ray Tubes	4
	A. Kinescope	
	B. Camera	
III.	Sync Generators	20
IV.	Television Cameras	30
V.	A. Deflection	
	B. Video	
	C. Correction	
	1. Peaking	
	2. Pedestal	
	3. Aperature	
	4. Gamma	
	5. White	
	6. Sensitivity	
	D. Blanking	
V.	Monitors	4
VI.	Supporting Equipment	4
	A. Equalizing Amplifiers	
	B. Insertion Special Effects	
	C. Video Switches	
VII.	Lighting	2
VIII.	Optics	2
IX.	Television Recording	4
		80

LABORATORY

1.	Video Composition and Oscilloscope Analysis	2
2.	CCTV Camera Set Up	4
3.	Sync Separation	4

4.	Deflection Circuits	18
	A. Oscillators	
	B. Sync Circuits	
	C. Output Circuits	
5.	Luminance Signals	8
6.	Chrominance Signals	4
		40
	TOTAL HOURS	120

COURSE OUTLINE

FIRST YEAR - FOURTH QUARTER

Task 10: Reports & Speech

Performance Objectives:

Write office and inter-department instructions, directives, memos, technical reports, and requisitions. Write a personal resumé suitable for job interview using appropriate writing models.

Criterion-Referenced Measure:

For a selected research topic, collect and present scientific and technical data in the organization of a technical report to the satisfaction of the instructor. Write a personal resumé of a quality that is acceptable for an industry interview for a job.

Description:

Techniques of collecting and presenting scientific and technical data. Informal reports and formal reports; special types of technical papers. Forms and procedures to be used in the writing of technical reports.

The subject matter of the student reports in this course will be taken from the electronics technology curriculum.

Performance Guide:

	MAJOR DIVISIONS	Suggested Hours
I.	The Scientific Method	9
II.	Design of the Report	24
III.	Form and Style of the Report	12
IV.	Criticism of the Report	15
		60

UNITS OF INSTRUCTION

I.	The Scientific Method	9
	A. Meaning of the Method	
	B. Characteristics of the Scientific Method	
II.	Design of the Report	24
	A. Definition	
	B. Four Important Procedures	
	C. Test of Progress	
	D. Primary Functions of the Introduction	
	E. The Paragraph	
	F. Use of Sectional Headings	
	G. Special Types of Paragraphs	
	H. The Terminal Section	
	I. Synopsis	
	J. The Rough Draft	
	K. The Short-form Report	
	L. The English of the Report	
III.	Form and Style of the Report	12
	A. Stenographic Details	
	B. Styling the Report	
	C. Format	
	D. Figures	
	E. Tables	
IV.	Criticism of the Report	15
	A. Finding the point of attack	
	B. A study of introductions	
	C. Studies in reorganization	
	D. Studies in Coherence	
	TOTAL HOURS	60

Task 11: Transistors II

Performance Objectives:

Be able to locate troubles in complex transistor circuits through a thorough knowledge of multistage transistor design. Find problems caused by temperature effects and stage frequency response. Apply h-parameter analysis to stage design and component selection.

Criterion-Referenced Measure:

Design and construct a high-frequency, broad-band multi-stage transistor amplifier that will work to industrial criteria and environmental specifications. Make a grade of 75 percent or higher on theory and laboratory objective tests.

Description:

Course is designed to compliment Transistors I. Includes a study of the A-C operation of the transistor amplifier, multi-stage amplifiers, temperature effects, and frequency response of transistor amplifiers. Also includes a study of h-parameters, and brief study of such special purpose devices as field-effect transistors, special diodes, and latching devices.

Performance Guide: THEORY

		Suggested Hours
I.	A-C Operation	10
	A. A-C Analysis of CE Circuits	
	B. Emitter Feedback	
	C. CC Operation	
	D. CB Operation	
	E. Effects of Source Resistance	
	F. Stabilizing the Voltage Gain from Source to Output	
	G. Maximum Signal-Handling Capability	
II.	Cascading Stages	12
	A. RC Coupling	
	B. Two-Stage Feedback	
	C. Inductive Coupling	
	D. Transformer Coupling	
	E. Tuned Amplifiers	
	F. DC Coupling	
	G. Difference Amplifiers	
III.	Temperature Effects	8
	A. Changes Due to Temperature	
	1. Emitter-Junction Resistance	
	2. Beta Changes	
	3. Changes in V_{be}	
	B. Leakage Current	
	1. Common Base	
	2. Common Emitter	
	C. The Stability Factor	
IV.	Frequency Response	
	A. Response of an RC Coupled Amplifier	14
	B. Common Base Stage	
	1. Lower Cut-Off Frequency	
	2. Upper Cut-Off frequency	
	C. Common Emitter Stage	
	1. Lower Cut-Off Frequency	
	2. Upper Cut-Off Frequency	
	D. Transistor Cut-Off Frequencies	
	E. Base Spreading Resistance	
	F. Response of Cascaded Stages	
V.	h Parameters	10
	A. The Concept of the h Parameters	
	B. Input impedance of a Network	
	C. Voltage Gain Using h Parameters	
	D. The h Parameters of a Transistor	
	1. Common Base	
	2. Common Emitter	
	3. Conversion of h Parameters	
VI.	Field-Effect Transistors	10
	A. The Junction Field-Effect Transistor	
	1. Biasing	
	2. Drain Curves	
	3. AC Operation	
	B. Depletion-Enhancement MOSFETS	

	C. Enhancement MOSFETS	
	D. Biasing MOSFETS	
	E. A-C Analysis of MOSFET Circuits	
VII.	Special Diodes	6
	A. Varactors	
	B. Step-Recovery Diodes	
	C. Schottky Diodes	
	D. Backward Diodes	
	E. Tunnel Diodes	
	F. PIN Diode	
VIII.	Latching Devices	6
	A. The Ideal Latch	
	B. The Four-Layer Diode	
	C. The SCR	
	D. The SCS	
	E. The Diac	
	F. The Triac	
IX.	Optoelectronic Devices	4
	A. Light-Emitting Diodes	
	B. LED Arrays	
	C. Laser Diodes	
	D. Photoresistors	
	E. Photodiodes	
	F. Phototransistors	
	G. Photo Detector Arrays	
		80

LABORATORY

1.	Two-Stage RC Coupled Amplifier	10
2.	Two-Stage Tuned, Transformer Coupled Amplifier	10
3.	Frequency Response of RC Coupled Amplifier	10
4.	Field-Effect Transistor Amplifier	6
5.	SCR Control Circuit	2
6.	The LED	2
		40
	TOTAL HOURS	120

Task 12: Test Equipment

Performance Objectives:

Obtain a working knowledge of the internal construction, circuits, and electrical limits of a basic set of electronic test units. Use this equipment within its design limits to make qualitative measurements in electronic circuits.

Criterion-Referenced Measure:

Build the basic measurement circuit and show that it will work for each of the measurement equipment types presented. Given industrial or laboratory

grade equipment, properly attach to a system to obtain meaningful measurement data to determine if the system is functioning correctly. Make a grade of 75 percent or higher on theory examinations.

Description:

Course begins with a study of basic meter movements and how their ranges can be extended. Course includes a study of various meters, signal generators, capacitance, inductance, and impedance measuring devices, and the oscilloscope. Also included is instruction concerning the care and use, and repair of all test equipment.

Performance Guide: THEORY

		Suggested Hours
I.	Basic Measurements and Electrical Laws	6
	A. Basic Meter Movements	
	B. Advantages and Disadvantages	
II.	Range and Function Versatility	6
	A. Extending Meter Range	
	1. Voltmeter	
	2. Ampmeter	
	3. Ohmmeter	
	B. Function Change	
	1. VOM	
	2. VTVM	
III.	Tube and Transistor Testers	6
	A. Filament Testers	
	B. Mutual-Conductance Tester	
	C. Diode and Transistor Testers	
	D. Transistor Curve Tracer	
IV.	Signal-Generators	6
	A. Basic Oscillator Circuits	
	1. Hartley Oscillator	
	2. Colpitts Oscillator	
	3. Tuned-Plate, Tuned-Grid Oscillator	
	4. Crystal Oscillators	
	5. Multivibrator Oscillator	
	6. Electron-Coupled Oscillator	
	7. Wien-Bridge	
	B. Generation of Non-Sinusoidal Signals	
	C. Generating Sweep Frequencies	
V.	Impedance Test	
	A. Capacitance Measurement	
	B. Inductance Measurement	
	C. VTVM Capacitance Test	
VI.	The Oscilloscope	6
	A. Types and Uses	
	B. Construction	
	C. Block Diagram	

D.	Circuit Study	6
	1. Vertical Amplifier	
	2. Horizontal Amplifier	
	3. Sweep Circuit	
	4. Power Supply	
		36

LABORATORY

I.	Simple Meters	4
	A. Voltmeter	
	B. Ohmmeter	
	1. Series	
	2. Shunt	
II.	Transistor and Tube Tester	4
	A. Conductance Test	
	B. Curve Tracer	
	C. Meter Test	
III.	Signal Generator	6
	A. Use of Generator	
	B. Simple Oscillator	
IV.	Use of Impedance Tester	4
V.	Use of Oscilloscope	6
		24
	TOTAL HOURS	60

Task 13: Lab Projects

Performance Objectives:

1. The student will produce each of the approved electronic solder joints to industrial standards.

2. The student will produce a usable electronic chasis, punching or filing all holes to a quality acceptable for field modification of existing commercial equipment.

3. The student will manufacture including layout, photo work, and drilling of a printed circuit card.

4. The student will produce a cable for interconnection of electronic equipment to include at least two multipin connectors and a barrier connector, properly laced and labeled.

Description:

Course is designed to give the student practice in proper techniques used in fabrication and repair of electronic equipment. Student will learn proper procedures for working metal chassis, planning and etching printed circuit boards and fabrication of electronic cables.

LABORATORY

		Hours
I.	Soldering	16
	A. Outside Chassis	
	B. Inside Chassis	
II.	Chassis Punching	16
	A. Drilling	
	B. Use of Greenley Punches	
	C. Nibbling	
III.	Bread Boarding	16
	A. Circuit Layout	
	B. Circuit Connection	
	C. Chect Out of Circuit	
IV.	Etched Circuit Fabrication	20
	A. Drawing to Scale	
	B. Photo Reducing	
	C. Etching	
	D. Drilling	
	E. Soldering	
V.	Cable Fabrication	16
	A. Plug Wiring	
	B. Cable Lacing	
	C. RF Cable Fabrication	
VI.	Chassis Layout Planning	20
	A. Spacing of Parts	
	B. Location of Controls	
	C. Positioning of Components	
	D. Routing of Wires	
VII.	DC Board Repair	16
	A. Broken Run Repair	
	B. Component Replacement	
	TOTAL HOURS	120

COURSE OUTLINE

SECOND YEAR - FIFTH QUARTER

Task 14: Industrial Electronics I

Performance Objective:

Obtain a working knowledge of the theory and solution techniques for problems in the industrial electronic and process control job area.

Criterion-Referenced Measure:

Produce a grade level of 75 percent or higher on examination in the subject material area.

Description:

This course is aimed at the theory and solutions techniques to many technician problems in the industrial electronics and process control areas. The emphasis is on theory, not equipment or laboratory work because many industrial and instrumentation systems require special circuits which are difficult to understand and must be treated mathematically if a solution is to be realized. The fundamental concepts and solution techniques are presented individually with ample problems to insure student understanding.

Performance Guide:

THEORY

		Suggested Hours
I.	Introduction	2
II.	Unit Exponential Function	6
III.	Decibel Conversion System	6
IV.	DC Meters	10
	A. Calibration Errors	
	B. Loading Effects	
	C. Shunts	
	1. Ammeter	
	2. Voltmeter	
	D. Sensitivity	
	E. Ohmmeter	
	F. VOM	
V.	Diodes	8
	A. Approximations I, II, III	
	B. Clippers	
	C. Clampers	
VI.	A-C Detection	8
	A. Half Wave	
	B. Low RMS Non-Linearity	
	C. Peak Detection	
	D. Loading Effects	
	E. P-P Detector	
VII.	Bridges	10
	A. Direct Current	
	1. Wheatstone	
	2. Potentiometer	
	3. Thevenin Equivalent	
	B. Alternating Current	
	1. Equivalent Impedances	
	2. Series-Parallel Conversion	
	3. Balanced Bridges	
	4. Commercial AC Bridges	
VIII.	Attenuators	16
	A. L-Type	
	B. Symetrical-T	
	C. Symetrical-PI	
	D. Bridged-T	
	E. Cascaded Sections	
	F. M-Derived	

IX.	Filters	14
	A. Pass	
	1. High	
	2. Low	
	3. Band	
	B. Rejection	
	1. High	
	2. Low	
	3. Band	
	C. Termination	
		80

LABORATORY

1.	Ammeter Calibration	2
2.	Voltmeter Calibration	2
3.	Wheatstone Bridge	4
4.	AC Bridge	4
5.	L-Attenuator	4
6.	Calibrated and Impedance-Matched T-Attenuator	6
7.	Low-Pass Filter	4
8.	High-Pass Filter	4
9.	Band-Pass Filter	4
10.	Band-Rejection Filter	6
		40
	TOTAL HOURS	120

Task 15: Instrumentation I

Performance Objective:

Obtain a working knowledge of an electronic process control system, input transducers(temperature, pressure, flow, volume) recording devices, strip chart recorders, indicators, alarms, output mechanisms (servos) and pneumatic valves as in current industry.

Criterion-Referenced Measure:

Produce a grade level of 75 percent or higher on written examinations in the subject matter area.

Description:

Instrumentation I is a first course in the study of measurement and control of processes used in industry. Included is a study of the theory of process quantities to be measured and controlled, such as, pressure, heat, flow, and weight. Also covered is the basic behavior of materials, energy and force systems.

Performance Guide: THEORY

		Suggested Hours
I.	Instrument Application	8
	A. The Process	
	B. The Types of Measurements	
	C. The Types of Instruments Available	
II.	Basic Behavior of Materials	8
	A. Changes Due to Temperature	
	B. Changes Due to Light	
	C. Strain and Stress	
III.	Basic Principles	8
	A. Weight, Mass, and Specific Gravity	
	B. Hydraulic and Pneumatic Principles	
	C. The "U" Tube Manometer	
IV.	Energy and Force Systems	8
	A. Types of Energy	
	B. Laws of Levers	
	C. Hydrodynamics	
	D. Types of Pneumatic and Hydraulic Amplifiers	
V.	Heat and Heat Transfer	8
VI.	Electrical Circuits and Devices	8
	A. Potentiometers	
	B. Electron Tubes	
	C. Transistors	
VII.	Alternating Current Circuits	8
	A. Induced Voltages	
	B. Transformers	
	C. Resistance, Reactance, and Impedance	
VIII.	Pressure Measurements, Mechanical Transducers	8
	A. Force Balance Gages (No Elastic Deformation)	
	B. Force Balance Gages (Elastic Deformation)	
	C. Absolute Pressure Gage	
	D. Differential Pressure Gage	
IX.	Pressure Measurements, Electrical Transducers	8
	A. Heat-Conduction Gages	
	B. Ionization Type Vacuum Gages	
	C. Mechanical-Electrical Pressure Transducers	
	D. Variable-Capacitance Gages	
	E. Manometer Transducers	
	F. Torque Balance Pressure Gages	
	G. Oscillator Type Pressure Current Transducers	
	H. Electro-Pneumatic Transducers	
X.	Liquid and Gas Flow Measurements, Mechanical Transducers	8
	A. Direct Volume Measurements	
	B. Positive Displacement Pump Measurements	
	C. Acceleration Type	
	D. Force of Fluid Impinging on an Obstruction	
	E. Speed of Propeller in Flow	
	F. Vane Torque	
	G. Orifice and Venturi	
		80

III.	A-C Circuit Analysis	20
	A. Review of Phase Angles	
	B. "j" Operator	
	C. Compensated Attenuator and Low Pass Filter	
	D. The Bode Plot	
	E. High Pass Filter and Band Pass Filter	
	F. Lead and Lag Networks	
	G. "Q" and Series Resonance	
	H. Band Width	
	I. Selectivity	
	J. Impedance Transformation	
	K. The Resonant Transformer	
IV.	Transient Analysis	16
	A. The Square Wave	
	B. The RC Circuit	
	C. Normalizing a Curve	
	D. The Time-Constant Chart	
	E. Rise and Fall Times	
	F. Interrelation of Transient and Frequency	
	G. Differentiating and Integrating a Wave Form	
V.	Transformers	16
	A. Mutual Impedance	
	B. Self-Impedance	
	C. Driving-Point Impedance	
	D. Transfer Impedance	
	E. The Dot Notation	
	F. Transformer Transfer Impedance	
	G. Current and Voltage Relationships	
	H. Equivalent Circuits	
	1. "T" Equivalent Circuit	
	2. Primary-Side Equivalent Circuit	
	3. Secondary-Side Equivalent Circuit	
VI.	Graphic Analysis of Vacuum-Tube Circuits	16
	A. Analysis of Characteristic Curves	
	B. Q-Point Evaluation	
	C. Plate Dissipation	
	D. Triode Parameters	
	E. The Tetrode	
	F. The Pentrode	
	G. Bias	
	1. Fixed Bias	
	2. Self-Bias	
	3. Combination	
	H. The Dynamic "Q" Point	
	I. The Dynamic Load Line	
	J. The Cathode Follower	
	K. The Grounded Grid Amplifier	
	L. The Cascode Amplifier	
		100

LABORATORY

1.	Three Loop Circuit	4
2.	Sine Wave Phase Shift	4
3.	The Resonant	4

LABORATORY

1.	The Thermocouple	5
2.	The Manometer	5
3.	The Pneumatic Amplifier	6
4.	The Transformer	6
5.	The D-P Cell	6
6.	Mechanical Pressure Transducer	6
7.	The Venturi and the Orifice	6
		40
	TOTAL HOURS	120

Task 16: Circuit Analysis

Performance Objective:

Obtain a thorough working knowledge of passive network analysis to include various solution methods such as current notation, loop and nodal analysis, determinants, complex numbers, j-Operator, Thevenization, Nortonization, Millman's Theorem and transient analysis.

Criterion-Referenced Measure:

Make a grade of 75 percent or higher on testing in the study area. Perform assigned experiments and produce an acceptable technical report to validate an understanding of material and solution techniques applied.

Description:

The course is a study of passive networks and various methods of analysis. Included in the course is notation, loop and nodal methods of analysis, determinants, complex numbers, and RC, RL, and RLC circuits. Vacuum-tube circuits are also analyzed.

Performance Guide:

THEORY

		Suggested Hours
I.	Notation, Voltage and Current Dividers	12
	A. Notation	
	B. Voltage Dividers	
	C. Current Dividers	
II.	Network Analysis and Theorems	20
	A. Superposition Theorem	
	B. Theve	
	C. Norton's Theorem	
	D. Millman's Theorem	
	E. Kirchoff's Voltage Law (Loop Analysis)	
	F. Determinants	
	G. Kirchoff's Current Law (Nodal Analysis)	

4.	The Differentiator	4
5.	The Triode Vacuum Tube	4
		20
	TOTAL HOURS	120

COURSE OUTLINE

SECOND YEAR - SIXTH QUARTER

Task 17: Industrial Electronics II

Performance Objectives:

Apply theory background to practical application in industrial and process control equipment including the mechanical to electrical/electronic interface containing MAG-AMPS, synchros, servos, control amplifiers, thyratrons, TRIAC's and SCR's.

Criterion-Referenced Measure:

Set up each application based experiment; remove any troubles or defective parts; obtain operational data and compile a technical report to industrial standards. Make a grade of 75 percent or higher for a cumulative written examination grade.

Description:

Industrial Electronics II carries the theory to practical application in industrial and process control applications. Process, mechanical to electrical interface, mag amps, synchros, servos, control systems, and sensing circuits are studied. Many of the electro-mechanical devices required by industry are investigated both in theory and in the laboratory. This course gives the student the background of information required to understand industrial electronic process control systems.

Performance Guide: THEORY

		Suggested Hours
I.	Transistor Review	10
II.	Amplifiers	20
	A. AC-DC	
	B. Equivalent Circuits	
	1. Theveninized	
	2. h-Parameter	
	C. Gain Formulas	
	D. Modulator - Demodulator	
	E. Phase Detector	
	F. Difference Amplifier	

III.	Electronic Voltmeter	10
	A. VTVM	
	B. DC-AC High Impedance Voltmeter	
IV.	Oscilloscope Fundamentals	6
V.	Harmonics	4
VI.	Harmonic Analysis Instruments	2
VII.	Signal Sources	4
VIII.	Transducers	6
IX.	Control Systems	6
X.	Electro-Mechanical Devices	12
	A. Relays	
	B. Synchros	
	C. Servos	
		80

LABORATORY

1.	Applications of Null Type Instruments	2
2.	Motors, Converters, Inverters, & Dynamotors	2
3.	Synchro Transmitter and Receiver	4
4.	Synchro Differential Transmitter and Receiver	2
5.	Synchro Control Transmitter	2
6.	Geared Synchro Systems	2
7.	Synchro Resolvers	2
8.	Basic Servo Systems	2
9.	Representative Servomechanism Systems	4
10.	Characteristics of a Saturable Reactor	4
11.	Application of a Saturable Reactor	2
12.	DC Shunt Motor Operation	2
13.	Thyratron Control of the Speed of a DC Motor	2
14.	Automatic Control of Motor Speed	4
15.	Regulated Electronic Power Supply	4
		40
	TOTAL HOURS	120

Task 18: Instrumentation II

Performance Objective:

Interconnect transducers, recorders, controllers, and control valves for a meaningful process control application. Obtain a working knowledge of more advanced measurement systems used in current standard industrial applications.

Criterion-Referenced Measure:

Set up assigned experiments using transducers (temperature, flow, level) controllers. Both indicating and registering with recorders, servo systems, both pneumatic and electronic, producing a stable minimal control system.

Show dynamic and static system operation, collect system data and write a technical report to industry standards. Make a grade of 75 percent or higher on related theory testing.

Description:

Instrumentation II is a second course in the study of measurement and control of processes used in industry. Included in this course are flow measurement with electrical transducers, measurement methods for such quantities as liquid-level, temperature, viscosity specific gravity and ph, and indicating and recording equipment.

Performance Guide:

THEORY

		Suggested Hours
I.	Flow Measurements, Electrical Transducers	8
	A. Magnetic Flowmeter	
	B. Turbine-Type Flowmeter	
	C. Strain Gage Flow Transducers	
	D. Variable Area Meters	
	E. Mass Flowmeters	
	F. Differential Transformers Transducers	
	G. Measuring Flow of Dry Materials	
II.	Liquid Level Measurements	8
	A. Position Measurement	
	B. Volume Determination	
	C. Weight Determination	
	D. Gage Glass	
	E. Pressure Gage	
	F. Purge or Bubbler System	
	G. Manometer Range Tube and Counterpoise	
	H. Float Systems	
	I. Capacitance Level Gaging	
III.	Temperature Measurements, Mechanical Transducers	8
	A. Nonelectrical Methods	
	1. Change in Volume of Liquid	
	2. Change in Pressure of Gas	
	3. Change in Vapor Pressure	
	4. Change in Dimensions of Solid	
	B. Electrical Methods	
	1. Thermocouples	
	2. Change in Resistance	
	3. Color Comparison	
	4. Temperature Measurement by Ascertaining the Energy Received by Radiation	
IV.	Temperature Measurements, Electrical Transducers	8
	A. The Resistance Thermometer	
	B. The Capacitance Bridge	
	C. Thermocouple	
	D. Radiation and Optical Pyrometry	

V.	Potentiometric Devices	8
	A. Automatic Potentiometers	
	B. Electronic Potentiometers	
	C. Oscillator Type Electronic Potentiometers	
VI.	Indicating and Registering Equipment	8
	A. Recording Devices	
	1. Circular Chart Instruments	
	2. Strip Chart	
	3. Pneumatic Strip Charts	
	B. Scanning Logging Systems	
VII.	Humidity Measurements	8
	A. Psychrometers	
	B. Hygrometers	
	C. Dew Point Determination	
	D. Determination of Moisture Content of Fabrics and Materials	
	E. Continuous Water Vapor Recorder	
VIII.	Specific Gravity and Viscosity Measurement	8
	A. Specific Gravity Measurements	
	B. Viscosity Measurements	
IX.	pH Measurements	8
	A. Meaning of pH	
	B. How to Measure	
	C. Principles of the pH Meter	
X.	Servo Systems	8
	A. Split Phase Meter	
	B. AC Amplifier	
	C. DC Motors	
	D. DC Amplifier	
	E. Closed Loop Systems	
		80

LABORATORY

1.	The Flowmeter	5
2.	The Level Detector	5
3.	The Thermocouple	5
4.	The Potentiometer	5
5.	The Strip Recorder	5
6.	The Hygrometer	5
7.	The pH Meter	5
8.	The Servo System	5
		40
	TOTAL HOURS	120

Task 19: Fortran

Performance Objective:

Obtain a working knowledge to a user level in the scientific/technician computer language Fortran-IV. Be able to use manufacturer supplied software

to exercise system for fault analysis. Be able to use the Fortran language to solve electronics problems as required in industry.

Criterion-Referenced Measure:

Successfully complete all assigned programs and supply a computer printout of the program, input data, and solutions. Make a grade of 75 percent on objective theory examinations.

Description:

Fortran (Formula Translation), an engineering and technician scientific language that closely resembles mathematics, is the industry accepted standard for troubleshooting and software diagnostic routines. This problem oriented language provides scientists, engineers, and technicians with a computer communications medium that is more familiar, easier to learn, and easier to use than systems based (Cobal) or machine base (Assembly) languages. This course places emphasis on program planning. Fundamental program techniques such as looping, flow charting, computed entry-exit are carefully explained. Applications related to all phases of the students course of electronic study are used to reinforce program study. All of the basic Fortran IV instruction set elements are studied with application on an operating system in the form of designated program laboratory assignments--machine operating experience is an integral part of the total course and therefore is not listed as a sub-section.

Performance Guide: THEORY

Suggested Hours

I. Introduction
II. Coding Form
    A. How the Columns are Used
        1. FORTRAN Statements
        2. Statement Numbers
        3. Program Identification, Sequencing
        4. Comments
        5. Blank
III. Constants, Variables, and Arrays
    A. Constants
        1. Integer Constants
        2. Real Constants
    B. Variables
        1. Variable Names
        2. Variable Types
        3. Subscripted Variables
    C. Arrays and Subscripts
        1. Arrangement of Arrays in Storage
        2. Subscript Forms

IV. Arithmetic Expressions
- A. Definition
- B. The Arithmetic Operation Symbols
- C. Computational Modes, Integer and Real
- D. The Mode of an Expression
  1. Integer and Real Mode Expressions
  2. Mixed Expressions
- E. Use of Parentheses
- F. Order of Operations

V. Statements
- A. Arithmetic Statements
- B. Control Statements
  1. Unconditional GO TO Statement
  2. Computed GO TO Statement
  3. IF Statement
  4. DO statement
  5. CONTINUE Statement
  6. PAUSE STATEMENT
  7. STOP Statement
  8. END Statement
  9. CALL Statement
  10 Special CALL Statement
  11. Machine and Program Indicator Tests
- C. Input/Output Statements
  1. Non-Disk I/O Statements
  2. Disk I/O Statements
  3. Unformatted I/O Statements
  4. Indexing I/O Statements
  5. Manipulative I/O Statements
  6. Logical Unit Numbers
  7. FORMAT Statement
- D. Specification Statements
  1. Type Statements (real, integer)
  2. EXTERNAL Statement
  3. DIMENSION Statement
  4. COMMON Statement
  5. Equivalence Statement
  6. DATA Statement
  7. DEFINE FILE Statement
- E. Sub-Program Statement
  1. Sub-Program Names
  2. Functions
  3. SUBROUTINE Sub-Program
  4. END and RETURN Statements in Sub-Program
  5. Sub-Programs Written in Assembler Language

120

COURSE OUTLINE

SECOND YEAR - SEVENTH QUARTER

Task 20: Switching Circuits

Performance Objective:

Obtain a thorough working knowledge of current logic modules and fabrication techniques. Be able to locate troubles on a logic block level and find the discrete part failure. Understand the design procedure and limitations in logic construction.

Criterion-Referenced Measure:

Build each logic circuit, locate any problems, exercise the circuit under the design criteria (voltage and temperature variation) to determine satisfactory operation. Write a technical report on each unit to industry standards. Make a grade level of 75 percent or higher on theory and design procedure testing.

Description:

A clear, concise, detailed explanation of digital circuitry is presented to the student. Each of the basic logic building blocks are studied from both design and maintenance stand points, with ample laboratory construction and experiments upon actual circuitry to reinforce understanding. Boolean Algebra and Karnaugh mapping techniques for logic simplification are introduced.

The course is based on the assumption that the student has a reasonable knowledge of transistor circuitry. Transistor I and II are pre-requisites.

Performance Guide:

THEORY

		Suggested Hours
I.	Pulse Waveforms	2
II.	Circuit Theorem Review	16
	A. Thevenin's Theorem	
	B. Norton's Theorem	
	C. Superposition	
	D. Millman's Theorem	
	E. Loop and Nodal Analysis	
III.	RC Networks	12
	A. RC Time Constants	
	B. Integrators-Differentiators	
	C. DC Restoration	

IV.	RL Networks	12
	A. Inductive Energy	
	B. L/R Time Constants	
	C. Pulse Transformers	
V.	The P-N Junction Diode	8
	A. Clippers	
	B. Clampers	
VI.	The Junction Transistor	10
	A. Fundamentals	
	B. Equivalent Circuits	
	C. Switching Characteristics	
VII.	Switching Amplifier Circuits	4
VIII.	Logic Circuits	16
	A. Logic Circuits	
	1. AND	
	2. OR	
	3. Inverter	
	4. NAND	
	5. NOR	
	B. Storage-Flip Flop	
	1. Astable	
	2. Monostable	
	3. Bistable	
		80

LABORATORY

1.	AND, OR Inverter Logic - 3010	2
2.	Solving Logical Equations	2
3.	The Flip-Flop	2
4.	Binary Number System	2
5.	Computer Codes	2
6.	Computer Arithmetic Operations	2
7.	The Steered Flip-Flop	2
8.	Shift Register and Memory Transfer	2
9.	Binary Codes	2
10.	Serial Synamic Memory	2
11.	Parallel Random Access Memory	2
12.	Serial Adder	2
13.	Gray Code Conversion	2
14.	Digital to Analog Converter	4
15.	Analog to Digital Converter	4
16.	Digital Voltmeter	4
17.	Arithmetic Unit 3010	2
		40
	TOTAL HOURS	120

Task 21: Communications I

Performance Objective:

Apply basic circuit design theory and tuning practices to transmitters, receivers, amplitude modulation, frequency modulation and antennas as necessary to properly align these devices. Know the equipment limitations and regulatory agency criteria, align and certify that the equipment meets these rules.

Criterion-Referenced Measure:

Completely align an amplitude-modulated transmitter and superhetrodyne receiver, a narrow-band VHF frequency-modulated public service radio system to include transmitter, receiver, with private line, and information multiplexing. Student is required to apply for the Federal Communications Commission Third Class Radio-Television License.

Description:

This course introduces the student to basic communications theory and measurements. The material covered includes basic theory, transmitters, receivers, amplitude modulation, frequency modulation, and antennas. The course meets all the requirements and procedures necessary to obtain a second and third class Radio Telephone, Federal Communications Commission License. Pre-requisites are Direct Current and Alternating Current.

Performance Guide:

THEORY

		Suggested Hours
I.	Basic Theory	5
	A. Current, Voltage, Resistance	
	B. Direct Current Circuits	
	C. Magnetism	
	D. Alternating Current	
	E. Inductance and Transformers	
	F. Capacitance	
	G. Alternating-Current Circuits	
	H. Resonance and Filters	
II.	Vacuum Tubes	1
III.	Solid State Devices	2
IV.	Power Supples	1
V.	Measurement Devices	5
VI.	Oscillators	6
VII.	Amplifiers	2
	A. Audio	
	B. Radio Frequency	
VIII.	Basic Transmitters	8
IX.	Amplitude Modulation	8
X.	Frequency Modulation	8

XI.	Receivers	8
	A. Amplitude Modulated	
	1. Superheterodyne	
	2. TRF	
	B. Frequency Modulated	
XII.	Antennas	6
XIII.	License Information	20
	A. Element 1, 2	
	B. Element 3	
		80

LABORATORY

1.	Transient Response of Tank Circuits	2
2.	Self-Exciting Oscillator Circuits	2
3.	Basic Types of Circuits	2
4.	Crystal Controlled Oscillators	2
5.	Radio Frequency Power Amplifiers	2
6.	Frequency Multipliers	2
7.	Amplitude Modulations	2
8.	Plate Modulation of Class Amplifiers	2
9.	Single-Sideband Suppressed Carrier	2
10.	Class B Modulator Related to Eg Ip Curve	2
11.	Frequency Modulated Receivers	2
12.	Modulation Index; Deviation Ratio; and Bandwidth	2
13.	Alignment Adjustments of FM Receivers	2
14.	Reactance Tube Modulators	2
15.	Limiter and Detector Circuit Analysis	2
16.	Discriminator-Ratio Detector Adjustment	2
17.	Radio Frequency Voltage Amplifiers	2
18.	Transmission Lines and Antennas	2
19.	Construction of Antennas	2
20.	Check SWR and Adjust for Minimum	2
		40
	TOTAL HOURS	120

Task 22: Microwave

Performance Objective:

Obtain the basic mathematical formulations, operating principles, and measurement procedures as applied to radar and microwave related assignments. Be able to identify and interconnect the basic set of microwave hardware, such as: Klystrons, Magnitrons, TR, ATR, Wave Guide Components, to build meaningful systems.

Criterion-Referenced Measure:

Perform a set of microwave and related experiments, show proper operation by data collection and compile a technical report to industry standards on each experiment. Obtain a grade level of at least 75 percent or more on all written examinations. Student is required to apply for an examination for the Federal Communications Commission Radar Endorsement to a second class radio telephone license.

Description:

A basic introductory course in theory and measurement for technicians in radar and microwave related jobs is pursued in this course. A concise treatment of microwave must also contain the mathematical formulations which illustrate fundamental principles and measurement procedures. Particular attention to technician procedures, problems, and application is given throughout the course. This course gives a good base of material upon which to study more advanced microwave concepts and techniques.

Performance Guide:

THEORY

		Suggested Hours
I.	Introduction to Field Theory	4
II.	Transmission Lines	6
	A. Two Wire Line	
	B. Traveling Waves	
	C. Reflecting	
	1. Terminated	
	2. Shorted	
	3. Open	
III.	Lines at Microwave Frequencies	4
	A. Traveling Waves	
	B. Propagation	
	C. SWR	
	D. Surge Impedance	
IV.	Use of Smith Chart	12
	A. Impedance-Admittance	
	B. Matching	
	C. Stub Tuner	
	1. Single	
	2. Double	
V.	Coaxial Transmission Lines and Measuring Equipment	4
VI.	Wave Guides	4
	A. Modes	
	B. Oblique Reflection	
	C. Operating Range	
	D. Dimensions	
	E. Impedance	
VII.	Wave Guide Elements and Components	6
	A. Matching Elements	
	B. Shorts	
	C. Tees	
	D. Shifters-Attenuators	
	E. Couplers	

	F. Detectors	
	1. Bolometers	
	2. Crystals	
	G. Joints	
	H. Antennas	
VIII.	Frequency Measurement Devices	6
	A. Resonators	
	1. Transmission Line	
	2. Cavity	
	B. Tuning Plungers	
	C. Wavemeters	
	D. Mode Chart	
	E. Filters	
IX.	Active Devices	10
	A. TWT	
	B. Backwave Oscillator	
	C. Klystron	
	D. Magnetron	
	E. Parametric Amplifiers	
X.	Measurement of Power	4
	A. Bolometric	
	B. Balanced Bridge	
	C. Calorimetric	
		60

LABORATORY

1.	Introduction and Lab Procedures	4
	A. Safety	
	B. Equipment Handling	
2.	Reflex Klystron Characteristics	6
3.	Frequency Measurement	4
4.	Power Measurement	4
5.	Attenuation Measurement	6
6.	Smith Chart	20
	A. Impedance--Admittance	
	B. Impedance Measurement	
	C. Filters	
7.	Bolometer Mounts	4
8.	Power Bridges	2
9.	Crystal Detectors	2
10.	Transmission Lines	4
	A. Mismatch Loss	
	B. Maximum Power Transfer	
11.	Directional Couplers	4
		60
	TOTAL HOURS	120

COURSE OUTLINE

SECOND YEAR - EIGHTH QUARTER

Task 23: Digital Machine Design

Performance Objective:

Be able to apply Boolean Algebra Equation Simplification and Karnaugh Mapping Techniques to logic reduction of sequential state machines and multistage logic systems in industrial controllers. Understand CPU and ALU operation as well as micro-processor organization and be able to trouble-shoot these systems.

Criterion-Referenced Measure:

Perform all assigned laboratory experiments and obtain correct logic operation. Make a grade level of 75 percent or higher on written examination

Description:

This course investigates advanced logic design and stabilization including noise immunity calculations. Boolean Algebra equation simplification and Karnaugh mapping of sequential state machines is covered as well as multistate industrial logic controller and computer CPU organization and troubleshooting techniques. Monolythic integrated circuit and MOS field effect transistor circuitry design and repair techniques are discussed.

Performance Guide: THEORY

		Suggested Hours
I.	Logic and Logic Circuits	4
	A. Number Systems	
	B. Logic Symbology	
	C. Advanced Boolean Algebra	
	D. Logic Circuit Design	
	E. Logic Circuits	
II.	Multivibrators	4
	A. Relaxation Oscillators	
	1. Gas Discharge	
	2. Astable	
	B. Bistable Multivibrators	
	C. Monostable Multivibrators	
	D. Schmitt-Trigger Circuits	
	E. Blocking Oscillators	
III.	Counters	8
	A. Binary	
	1. Up Counters	
	2. Down Counters	
	3. Programmable Counters	

	B. Permuted Counters	
	C. Shift Register	
	D. Ring Counters	
IV.	Matrices	8
	A. Decoding	
	B. Encoding	
V.	Special Circuits and Devices	10
	A. Linear Operational Amplifiers	
	B. Pulse Amplifiers	
	1. Linear Single Ended	
	2. Push-Pull	
	C. Differential Amplifiers	
	D. CRT Deflection Amplifiers	
	E. Non-Linear Read-Write Amplifiers	
	F. Sawtooth Generator	
	G. Staircase Generator	
	H. Special Devices	
VI.	Integrated Circuits	6
	A. Manufacturing Processes	
	B. Linear	
	C. Switching and Gating	
	D. IC Multivibrators	
	E. MSI and LSI	
	F. MOS integrated Circuits	
		40

LABORATORY

1.	Advanced Digiac 3010 Experiments	4
	A. Use of Input Dial	
	B. Output Display	
2.	Octal to Decimal Counter Using Display	2
3.	Counters and Timers Using Display	6
4.	Automatic Digital/Analog Converters	8
5.	Arithmetic Operation Using Digiac 3010 Display	6
6.	Introduction to the Digiac 3050	6
	A. Controls	
	B. Add and Transfer	
	C. Problem Solution	
7.	Machine Programming	4
	A. Problem Analysis	
	B. Flow Charts	
8.	Diode Gated Logic Circuits	4
	A. AND Gate	
	B. OR Gate	
	C. Inverter	
	D. NAND Gate	
	E. NOR Gate	
9.	Direct Coupled Transistor Logic	2
	A. NAND Circuit	
	B. NOR Circuit	

10.	Flip-Flop and Clock	4
11.	Lamp Drivers and Power Supply	2
12.	Arithmetic Unit	6
	A. Registers	
	B. Counters	
	C. Adders	
	D. Subtracters	
13.	Control Unit	6
	A. Synchronization	
	B. Instruction Register	
	C. Sequence Counter	
	D. Phase Sequencer	
14.	Troubleshooting the Digiac 3050	20
		80
	TOTAL HOURS	120

Task 24: Communications II

Performance Objective:

Obtain a working knowledge of installation, maintenance, and operation of commercial broadcast transmitting and receiving equipment. Be able to apply all regulatory rules and regulations for both technician and equipment.

Criterion-Referenced Measure:

Make a grade level of 75 percent or higher on theory and license examinations. Perform the assigned laboratory experiments, obtain data proving correct operation and write a technical report on each. Student is required to apply for the Communications Commission Second Class Radio-Telephone License.

Description:

Material covered in this course gives the student a background in installation, maintenance, and operation of commercial broadcast transmitting and receiving equipment. Broadcast engineering level electronic procedures, communications electronics, and industrial electronics that emphasize communications theory are covered. The course covers all regulations and theory necessary to obtain a First Class Radio-Telephone Federal Communications Commission License. Pre-requisite is Communications I.

Performance Guide:

THEORY

		Suggested Hours
I.	Advanced Theory	12
	A. LCR Circuits	
	1. Filters	
	2. Resonance	
	3. Matching Networks	

	B. Tubes	
	1. Operating Theory	
	2. Special Types	
	C. Solid State Devices	
	D. Complex Circuits	
II.	Power Supplies	4
	A. DC to DC	
	B. High Power AC to DC	
III.	Measurement Devices	2
IV.	Oscillators	8
	A. Types	
	B. Maintenance	
V.	Amplifiers	2
	A. Audio Frequency	
	B. Radio Frequency	
VI.	Transmitters	8
	A. AM	
	B. FM	
	C. T.V.	
VII.	Antennas	4
	A. Types	
	B. Gain	
	C. Field Strength	
VIII.	Frequency Measurement	2
IX.	Batteries	2
X.	Motor Generator Sets	2
XI.	Broadcast Stations	4
XII.	Television	10
XIII.	License Information	20
	A. Second Class Revised	
	B. Element 4	
		80

LABORATORY

1.	Transient Response of Tank Circuits	2
2.	Self-Exciting Oscillator	2
3.	Basic Types of Circuits	2
4.	Crystal Controlled Oscillators	2
5.	Radio Frequency Power Amplifiers	2
6.	Frequency Multipliers	2
7.	Amplitude Modulations	2
8.	Plate Modulation of Class Amplifiers	2
9.	Single-Sideband Suppressed Carrier	2
10.	Class B Modulator Related to Eg-Ip Curve	2
11.	Frequency Modulated Receivers	2
12.	Modulation Index; Deviation Ratio; and Bandwidth	2
13.	Alignment Adjustments of FM Receivers	2
14.	Reactance Tube Modulators	2
15.	Limiter and Detector Circuit Analysis	2
16.	Discriminator and/or Ratio Detector Adjustment	2

17.	Radio Frequency Voltage Amplifiers	2
18.	Transmission Lines and Antennas	2
19.	Construction of Antennas	2
20.	Check SWR and Adjust for Minimum	2
	TOTAL HOURS	120

Task 25: Term Project

Performance Objective:

To exercise the manipulative skills in the design and construction practice area. Apply shop construction techniques in electronic circuit and machine design.

Criterion-Referenced Measure:

Build a working construction project to current industry standards with accompanying instructional manual and schematic diagrams.

Description:

This is a laboratory course designed to exercise the technical achievement of the student in the area of construction practice and skill. All previous electronics knowledge will be required to successfully complete this course. Each student is interviewed, an area of student interest is determined, and an individual project is assigned for (original construction or reconstruction). Emphasis is placed on quality of work both hardware and reports, as well as practices and safety requirements are followed closely.

Performance Guide: LABORATORY

		Suggested Hours
I.	Project Definition	20
	A. Research	
	B. Report-Evaluation	
II.	Prototype	40
	A. Handwired Construction	
	B. Debugging	
	C. Redesigned	
III.	Final Production	40
	A. Printed Circuit Drawings	
	B. PC Construction	
	1. Photo Work	
	2. Drilling and Sizing	
	C. Parts Insertion	
	D. Final Test	
	1. Evaluation	
	2. Redesign	

IV.	Project Report	20
	A. Proof of Operational Performance	
	B. Project Manual	
	1. Specifications	
	2. Operating Instructions	
	3. Schematics	
	4. Parts Placement	
	5. Parts List	
	6. Cost of Project	
	TOTAL HOURS	120

ENGINEERING TECHNOLOGY

Associate Degree Program

Introduction

A growing gap has developed between the functions of the highly educated professional engineer (or scientist) and the highly skilled craftsman. As our technological development increases, the gap is, unfortunately, also increasing. The engineering technician is playing a vitally important role in bridging the communications gap between the two. This preface will identify the engineering technician, explain the present and potential needs for these occupations, describe the preparatory programs needed for this occupational cluster of jobs, and present programs that are typical for this kind of education.

The American Society for Engineering Education (ASEE) assigns the following definition to engineering technology:

> Engineering Technology is that part of the engineering field which requires the application of scientific and engineering knowledge and methods combined with technical skills in support of engineering activities; it lies in the occupational area between the craftsman and the engineer, at the end of the area closest to the engineer.

At this point it would be expedient to identify the members of the engineering team. They are:

Technical Manager
Scientist
Engineer
Technician
Craftsman

Notice that the technician occupies the job cluster area between the engineer and the craftsman.

Technicians are divided generally into two categories: engineering technician and industrial technician. The main difference between these two categories lies in their educational orientation. The industrial technician has an educational background that makes him more of a job-oriented person,

and it is usually of narrower scope than the educational background of the engineering technician. The industrial technician will probably have had courses in machine shop, air conditioning, television, or diesel engine maintenance or repair. The engineering technician is usually a field-oriented person with an education of a broader scope than the industrial technician. He will have some breadth in chemical, electrical, mechanical or construction technology. The education and training of the engineering technician enables him to work more closely with the engineer. But both are able to relate to the engineer and the skilled craftsman.

The needs for technicians in industry are almost unlimited. The ideal situation with regard to manpower distribution is ten skilled craftsmen, five industrial technicians and three engineering technicians for every scientist and engineer. But such is not the case. In 1960 the National Science Foundation reported that 600,000 were employed in industry, which meant that there were seven technicians employed to every ten engineers. This falls terribly below the desired ratio. In order to supply the needed 3:1 ratio, the National Science Foundation stated that nearly six million technicians would be needed. An American Society for Engineering Education survey in 1965 shows the ratio to be much lower than the National Science Foundation figures--42 technicians to every 100 engineers. In 1971 the Bureau of Labor Statistics stated that the ratio of technicians to scientists and engineers is projected to be 63 technicians to every 100 scientists and engineers through 1980. Although these different surveys may differ on the exact figures for describing the shortage problem, they all concur that there is a tremendous shortage of needed technicians. Thus, the employment opportunities for properly educated and trained technicians are tremendous.

The academic preparation for the student desiring to enter a post-secondary program for technician education is very similar to any student

desiring a college education. It is desirable for the student to have three to four units of English. Three units in mathematics is also expedient, preferably two units of algebra and one of plane geometry. A unit in trigonometry would also place the student at an advantage but is not mandatory. The elements of algebra, trigonometry and calculus are taught in technical, associate-degree programs. This math, however, is taught from an applications viewpoint and not from the viewpoint of proving mathematical theories and laws. The student is taught how to apply his mathematical knowledge to his technical specialty. This covers the academic preparation for the aspiring technician, but the main quality he should possess is an overwhelming curiosity about how things work. He is really "turned on" by the why of observed phenomena, be it electrical, mechanical or pneumatic. Mechanical aptitude and the ability to visualize things (and manual dexterity) are also desirable traits. Students who possess these traits, coupled with a desire to learn (be it in a theoretical lecture or a practical laboratory situation) can probably overcome any deficiencies that may exist in his previous academic preparation and go on to become an excellent technician.

The Engineer's Council for Professional Development, which is the recognized accrediting agency for technical institute curricula, has established the following guide for curricula, based on an average of 71 semester hours for completion:

Technical Specialty	35 hours	19.0%
Mathematics	9 hours	12.8%
Science	9 hours	12.8%
Auxilliary Technical Courses	7 hours	9.9%
General Education	11 hours	15.5%

Engineering technology curricula, are post-secondary and are college-level programs. The extent of the mathematics in the curriculum determines the level

of the program. Engineer's Council for Professional Development-accredited schools cover college-level algebra and trigonometry, differential and integral calculus and touches elements of differential equations and other aspects of higher mathematics. The sciences covered in the curriculum are physics, chemistry and some of the engineering sciences. The non-technical courses included in the curriculum are technical writing, social science, speech and industrial orientation.

This introduction has given the general idea and definitions of the engineering technician. In summary, students who do not have an interest or aptitude for the comprehensive theory and advanced mathematics of the professionally-oriented programs in engineering and science, a career as an engineering technician can be richly rewarding. They work as aides and assistants to engineers, as well as supervise other technicians and craftsmen. Their educational experience is different from that of the engineer in that the technician's educational background is more toward practical application as opposed to theoretical innovation. The educational program is post-secondary, usually two years in length, and awards the degree of Associate of Science upon successful completion.

Task 1: Network Analysis

Performance Objective:

The learner will be given certain design parameters, along with a desired response, that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level, with the 80 percent level being considered as successful. This will be a written exam lasting two hours.

Performance Guide: THEORY	Suggested Hours
I. Basic Electrical Theory	3
A. Atomic Structure	
B. Conductors, Insulators and Semiconductors	
C. Static Charges	
1. Attraction and Repulsion of Charges	
2. Electrostatic Fields	
D. Units of Electrical Measurements	
1. Coulomb	
2. Ampere	
3. Volt	
4. Ohm	
II. Basic Circuit Analysis	12
A. Electrical Resistance	
1. Color Code	
2. Types and Uses of Resistors	
B. Ohm's Law	
1. Current	
2. Voltage	
3. Resistance	
4. Conductance	
C. Resistive Networks	
1. Series Circuits	
2. Parallel Circuits	
3. Series-Parallel Circuits	
D. Power	
1. Formulas	
2. Applications to Resistive Circuits	

E. DC Sources
   1. Batteries
   2. Generators and Other Sources

III. Network Theorems — 6
   A. Kirchoff's Laws
   B. Thevenin's and Norton's Theorems
   C. Superposition Theorem
   D. Delta-Wye Transformation
   E. Maximum Power Transfer
   F. Ideal Voltage and Current Sources

IV. Electromagnetism, Inductance and Capacitance — 6
   A. Permanent and Electromagnets
      1. Domain Theory
      2. Magnetic Fields
      3. Hysteresis
   B. Principles of Inductance
      1. Basic Definition and Lenz's Law
      2. Voltage-Current Relationship
      3. RL Time Constant and Equations
      4. Series and Parallel Inductance
      5. Types and Measurement of Inductance
   C. Capacitance
      1. Basic Definition and Coulomb's Law
      2. Voltage-Current Relationships
      3. RC Time Constant and Equations
      4. Series and Parallel Capacitance
      5. Types and Measurement of Capacitance

V. Sinusoidal Waveforms — 3
   A. The Sine Wave
      1. Generation
      2. Induced Electromotive Force (EMF)
   B. Sinusoidal Amplitude Displacement
      1. Instanteneous Value
      2. Peak Value
      3. Peak-to-Peak Value
      4. RMS Value
   C. Sinusoidal Time Displacement
      1. Frequency
      2. Period
      3. Phase Relationships

VI. RLC Networks — 9
   A. Inductive Reactance
   B. Capacitive Reactance
   C. Vectors and j-Operators
   D. Impedance
      1. RL Series and Parallel Circuits
      2. RC Series and Parallel Circuits
      3. RLC Series and Parallel Circuits
      4. Conductance, Susceptance and Admittance
      5. Impedance Network Theorems

VII.	Resonant Circuits	6
	A. Series Resonance	
	1. Circuit Q	
	2. Resonant Rise of Voltage	
	3. Selectivity	
	B. Parallel Resonance	
	C. Filter Networks	
	D. Maximum Power Transfer	
VIII.	Transformers	3
	A. Transformer Basics	
	1. Transformer Action and Ratios	
	2. Impedance Transformation	
	3. Open and Short Circuit Tests	
	B. Types of Transformers	
	1. Auto Transformers	
	2. Audio and Power Transformers	
	3. Tuned Transformers	
	TOTAL	48

LABORATORY

		Suggested Hours
1.	Resistor Color Code, Tolerance and Ohm's Law	4
2.	Series Circuits and Kirchoff's Law	8
3.	Parallel Circuits and Kirchoff's Law	8
4.	Series-Parallel Circuits	8
5.	Maximum Power Transfer	4
6.	Superposition, Thevenin's and Norton's Theorems	8
7.	Electromagnetism and Inductance Characteristics	2
8.	RL Time Constants	2
9.	Electrostatics and Capacitance Characteristics	2
10.	RC Time Constants	2
11.	AC Voltage and Phase Angle Measurement with Oscilloscope	4
12.	Series and Parallel RC Impedance	2
13.	Series and Parallel RL Impedance	2
14.	Series and Parallel Complex Impedance	2
15.	Series and Parallel Resonance	4
16.	Transformer Characteristics	2

Task 2: Electronic Principles I

Performance Objective:

The learner will be given certain design parameters, along with a desired response, that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level, with 80 percent level being considered as successful. This will be a written exam lasting two hours.

Performance Guide: THEORY

		Suggested Hours
I.	Semiconductor Physics	3
	A. Classification of Matter	
	B. Conductors, Semiconductors, and Insulators	
	C. Covalent Bonding in Semiconductors	
	D. Doping Techniques in Semiconductors	
	E. Temperature Effects on Semiconductors	
II.	Semiconductor Diodes	6
	A. Depletion Region and Contact Potential	
	B. Forward and Reverse Bias	
	C. Diode Characteristics	
	D. Zener Diodes Characteristics	
	E. Zener Regulators and Applications	
III.	BJT Characteristics and Bias Stability	12
	A. BJT Structure and Operation	
	B. BJT Static Characteristics and Thermal Stability	
	C. The Common Emitter Configuration	
	D. The Common Base Configuration	
	E. The Common Collector Configuration (Emitter Follower)	
	F. BJT Specifications and Ratings	
IV.	FET Characteristics and Biasing Techniques	9
	A. JFET Characteristics and Parameters	
	B. Biasing the JFET	
	C. The Common Source Configuration	
	D. The Common Gate Configuration	
	E. The Common Drain Configuration (Source Follower)	
	F. MOSFET Characteristics and Parameters	
	G. Biasing the MOSFET	

V.	Vacuum Tube Characteristics	6
	A. Vacuum Tube Construction and Characteristics	
	B. Vacuum Tube Diodes, Parameters and Applications	
	C. Vacuum Tube Triodes, Parameters and Applications	
	D. Vacuum Tube Pentodes, Parameters and Applications	
VI.	UJT's and Thyristors	6
	A. UJT Characteristics and Parameters	
	B. UJT Circuit Operation	
	C. SCR and TRIAC Characteristics and Parameters	
	D. SCR and TRIAC Circuit Operation	
VII.	Optoelectronics	6
	A. The Nature of Light	
	B. Photoconductive and Photovoltaic Cells	
	C. Photodiodes and Phototransistors	
	D. LED's, Optocouplers and Optoisolators	
	TOTAL	48

LABORATORY

1.	Semiconductor Diode Characteristics and Applications	3
2.	Zener Diode Characteristics and Applications	3
3.	BJT Characteristics	3
4.	BJT Biasing Configurations and Thermal Characteristics	6
5.	BJT Characteristic Curves and Graphical Analysis	3
6.	JFET Characteristics	3
7.	JFET Biasing Characteristics	3
8.	MOSFET Characteristics	3
9.	Vacuum Diode Characteristics and Applications	3
10.	Vacuum Triode Characteristics and Applications	3
11.	UJT Characteristics and Applications	3
12.	Thyristor Characteristics and Applications	3
13.	Photovoltaic Cell Characteristics and Applications	3
14.	LED and Phototransistor Characteristics and Applications	3
15.	Optocoupler Characteristics and Applications	3

Task 3: Electronic Principles II

Performance Objective:

The learner will be given certain design parameters along with a desired response that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot, and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level with the 80 percent level being considered as successful. This will be a written exam lasting two hours.

Performance Guide: THEORY

		Suggested Hours
I.	Rectifiers and Filters	6
	A. Rectification Principles	
	B. Half-Wave Rectification	
	C. Full-Wave Rectification	
	D. Filtering Techniques	
	E. Simple Regulator Circuits	
II.	Basic Amplifier Principles	9
	A. Amplifier Input and Output Ports	
	B. Amplification Basics and Hybrid Parameters	
	C. Single-Stage BJT Amplifier	
	D. Single-Stage FET Amplifier	
	E. Frequency Response Analysis	
III.	Practical Amplifier Considerations	12
	A. Input and Output Impedance	
	B. Real and Apparent Gain	
	C. Amplifier Loading	
	D. Impedance Matching	
	E. Cascaded Amplifiers	
IV.	Feedback Principles	9
	A. General Feedback Concepts	
	B. Voltage Feedback Amplifiers	
	C. Current Feedback Amplifiers	
	D. Feedback and Frequency Response	
	E. Series and Shunt Feedback Amplifiers	
	F. Feedback and Distortion	
V.	Power Amplifiers	6
	A. Classification of Power Amplifiers	
	B. Series-Fed Class A Amplifiers	

	C. Power Considerations	
	D. Computation of Harmonic Distortion	
	E. Transformer-Coupled Single-Ended Class A Amplifiers	
	F. Transformer-Coupled Push-Pull Amplifiers	
	G. Complimentary-Symmetry Amplifiers	
VI.	Differential and Operational Amplifiers	6
	A. Emitter Follower	
	B. Differential Amplifiers	
	C. Integrated Circuit DIFF AMPS	
	D. Operational Amplifiers (OP-AMPS)	
	E. Inverting and Non-Inverting OP-AMPS	
	F. Additional OP-AMP Circuits	
	TOTAL	48

LABORATORY

1.	Rectification and Filtering Characteristics	3
2.	Zener Diode and Series-Pass Regulators	3
3.	BJT Hybrid Parameters	3
4.	BJT Amplifier Characteristics	3
5.	JFET Amplifier Characteristics	3
6.	Amplifier Frequency Response and Bode Plots	3
7.	Amplifier Input and Output Impedance	3
8.	Amplifier Loading and Impedance Matching	3
9.	Cascade Amplifier Characteristics	3
10.	Feedback Characteristics	3
11.	Voltage and Current Feedback	3
12.	Series and Shunt Feedback	3
13.	Class A Power Amplifiers	3
14.	Class AB Power Amplifiers	3
15.	Differential Amplifier Characteristics	3
16.	Basic OP-AMP Configurations	3

Task 4: Pulse and Switching Circuits

Performance Objective:

The learner will be given certain design parameters, along with a desired response, that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level, with the 80 percent level being considered as successful. This will be a written exam lasting two hours.

Performance Guide: THEORY

		Suggested Hours
I.	Complex Waveform Analysis	6
	A. Rectangular Pulses	
	1. Ideal Rectangular Pulses	
	2. Practical Rectangular Pulses	
	3. Periodic Pulse Waveforms	
	4. Trigger Pulse	
	B. Frequency Analysis	
	1. Harmonic Content	
	2. Linear Networks	
	3. Aperiodic Waveforms	
II.	Passive Device Networks	9
	A. RC Circuit Basics	
	B. Exponential Form and Applications	
	C. RC Response to Various Inputs	
	1. Rectangular Pulse Input	
	2. Non-Ideal Input	
	3. Sweep Input	
	4. Natural and Forced Response	
	D. RL Circuit Basics	
	E. Exponential Form and Applications	
	F. RLC Series and Parallel Circuits	
III.	Diode Switching Circuits	6
	A. Basic Diode Characteristics	
	B. Basic Diode Circuits	
	C. Diode Clipper and Clamper Circuits	
	D. Diode Transient Characteristics	
IV.	Transistor Switching Circuits	6
	A. Basic Transistor Operation	
	B. Transistor Circuit Analysis	
	C. Basic Transistor Inverter	
	D. Loading Effects and Transient Operation	

V.	Multivibrator Circuits	9
	A. Bistable Multivibrator	
	1. Basic Circuit Operation	
	2. Triggering Techniques	
	3. Applications	
	B. Monostable Multivibrator	
	1. Basic Circuit Operation	
	2. Triggering Techniques	
	3. Applications	
	C. Astable Multivibrator	
	1. Basic Circuit Operation	
	2. Applications	
VI.	Signal Generating and Comparator Circuits	9
	A. Signal Generating Circuits	
	1. Sweep Voltage Generators	
	2. Solid State Sweep Generator	
	3. Constant Current Sweep Generator	
	4. Relaxation Oscillator	
	5. Staircase Generator	
	B. Comparator Circuits	
	1. Schmitt Trigger Circuit	
	2. Schmitt Trigger UTP and LTP	
	3. Differential Amplifier Comparator	
VII.	Logic Family Comparisons	3
	A. Various Logic Families	
	1. RTL	
	2. DTL	
	3. TTL	
	4. CMOS	
	B. Comparison of Characteristics	
	1. Noise Margin	
	2. Fan-In and Fan-Out	
	3. Power Dissipation	
	4. Switching Speed	
	TOTAL	48

LABORATORY

1.	Rectangular Waveform Generation	3
2.	Rectangular Waveform Characteristics	3
3.	RC Circuit Response to Rectangular	3
4.	RL Circuit Response to Rectangular Waveforms	3
5.	RLC Circuit Response to Rectangular Waveforms	3
6.	Diode Clipper Circuits and Applications	3
7.	Diode Clamper Circuits and Applications	3
8.	Transistor Inverter Characteristics	3
9.	Transistor Inverter Loading Effects	3
10.	Bistable Multivibrator Circuits and Applications	3
11.	Monostable Multivibrator Circuits and Applications	3
12.	Astable Multivibrator Circuits and Applications	3
13.	Constant Current Sweep Generator	3
14.	Relaxation Oscillator	3
15.	The Schmitt Trigger	3
16.	Characteristics of Logic Families	

Task 5: Digital Principles

Performance Objective:

The learner will be given certain design parameters along with a desired response that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot, and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level with the 80 percent level being considered successful. This will be a written exam lasting two hours.

Performance Guide:

THEORY
DIGITAL PRINCIPLES

		Suggested Hours
I.	Number Systems	6
	A. Introduction to Number Systems	
	1. Decimal and Binary Systems	
	2. Binary Counting	
	3. Octal Systems	
	B. Arithmetic Processes	
	1. Binary Addition, Subtraction, Multiplication and Division	
	2. Octal Addition, Subtraction, Multiplication and Division	
	3. Binary, Octal and Decimal Conversion	
	4. Negative Number Techniques	
	5. Number Complements	
	6. BCD Number Representation	
II.	Boolean Algebra and Reduction Techniques	12
	A. Boolean Algebra Basics	
	1. AND, OR and INVERT Functions	
	2. Basic Boolean Laws	
	3. DeMorgan's Theorems	
	B. Evaluation of Logical Expressions	
	1. Proof by Perfect Induction	
	2. Boolean Algebra Reduction	
	3. Sum-of-Products Techniques	
	4. Product-of-Sums Techniques	
	5. Karnaugh Mapping Reduction	
	C. Implementation of Logic Functions	
	1. Application of DeMorgan's Theorem to Gating Networks	
	2. Interpreting Logic Diagrams	
	3. Implementing Logic Expressions	

III. Counters and Registers — 9
- A. Flip-Flops
  - 1. RS Flip-Flop
  - 2. RST Flip-Flop
  - 3. Type D Flip-Flop
  - 4. JK Flip-Flop
- B. Counter Circuits
  - 1. Asynchronous Binary and BCD Counters
  - 2. Synchronous Binary and BCD Counters
  - 3. Down Counters
  - 4. Up-Down Counters
  - 5. Shift Counters
- C. Register Circuits
  - 1. Parallel Registers
  - 2. Shift Registers
  - 3. Left-Right Shift Registers
  - 4. Recirculating Shift Registers

IV. Encoders, Decoders and Code Converters — 6
- A. Encoding
- B. Decoding
  - 1. BCD-to-Decimal Decoders
  - 2. Hexadecimal Decoders
  - 3. Seven-Segment Decoders
- C. Code Converters
- D. Multiplexers, Gating, and Data Steering

V. Timing Techniques — 3
- A. Clock Cycles
- B. Multiphase Clock Pulses
- C. Timing in Electronic Calculators
- D. Clock Cycle Modification
- E. Sequencing Operations

VI. Arithmetic Logic Techniques — 6
- A. Half and Full Adders
- B. Half and Full Subtracters
- C. Serial and Parallel Adders
- D. Logic Decisions
- E. BCD Adders and Subtracters

VII. Memory Systems — 6
- A. Magnetic Core Memories
- B. Bipolar Memories
  - 1. Bipolar RAM
  - 2. Bipolar ROM
- C. MOS Memories
  - 1. MOS RAM
  - 2. MOS ROM
- D. ROM Applications
  - 1. Code Converters
  - 2. Character Generators
  - 3. Look-Up Tables
  - 4. Micro-Programming

TOTAL — 48

LABORATORY

		Suggested Hours
1.	Basic Logic Functions	3
2.	Boolean Algebra and Simplification of Logic Expressions	3
3.	DeMorgan's Theorems	3
4.	Basic Flip-Flop Circuitry	3
5.	Binary Counters: Asynchronous and Synchronous	3
6.	Divide-by-N Counters: Asynchronous and Synchronous	3
7.	Decoders and Indicator Systems	3
8.	Shift Registers and Ring Counter	3
9.	Frequency Counter Design Project	6
10.	Exclusive OR Gate	3
11.	Adders and Subtracters	3
12.	A.L.U. Techniques and Applications	3
13.	Semiconductor Memory Systems	3
14.	Memory System Design Project	6

Task 6: Communication Systems I

Performance Objective:

The learner will be given certain design parameters, along with a desired response that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot, and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level with the 80 percent level being considered successful. This will be a written exam lasting two hours.

Performance Guide: THEORY

	Suggested Hours
I. Review of Resonant Circuits	6
A. Series-Tuned Circuits	
1. Q-Rise in Voltage	
2. Frequency Effects	
3. Circuit Resistance Effects	
4. Sharpness of Resonance	
B. Tank Circuits	
1. Resonant Relations	
2. Parallel Circuit Impedance	
3. Circulating Current	
4. Frequency and Series Resistance Effects	
5. Gain and Bandwidth	
II. Circuit Coupling	3
A. Types of Coupling	
1. RC Coupling	
2. Impedance and Transformer Coupling	
3. Direct Coupling	
B. RF Filter Circuits	
1. Low-Pass Filters	
2. High-Pass Filters	
3. Band-Pass Filters	
4. Band-Reject Filters	
5. L and Pi-Type Filters	
C. Impedance Matching	
1. Direct-Coupled Matching	
2. Inductive-Coupled Loads	
3. Pi Network Impedance Matching	

III. RF Voltage Amplifiers 9
- A. Impedance-Coupled RF Amplifiers
  - 1. Gain and Bandwidth
  - 2. Multi-Stage Response and Stagger Tuning
  - 3. Shielding
- B. Single-Tuned, Transformer-Coupled Amps
  - 1. Gain
  - 2. Bandwidth
- C. Double-Tuned, Transformer-Coupled Amps
  - 1. Gain
  - 2. Bandwidth
- D. High Frequency Circuits
  - 1. Grounded-Grid Amplifiers
  - 2. Cathode-Coupled Amplifiers
  - 3. Cascade Amplifiers
- E. Transistor RF Amps
  - 1. Coupling Methods
  - 2. Neutralization

IV. RF Power Amplifiers 9
- A. Class C Amplifiers
  - 1. Voltage and Current Relationships
  - 2. Definition of Terms
  - 3. Grid Bias Circuits
  - 4. Tank Circuit Considerations
  - 5. Coupling Methods
- B. Neutralization
  - 1. Neutralizing Circuits
  - 2. Neutralizing Techniques
  - 3. Parasitic Oscillations
  - 4. Tuning Adjustment
  - 5. Frequency Multipliers
- C. Class B Linear Amplifiers
- D. Transistor and RF Power Amplifiers
  - 1. Bias Voltages
  - 2. Neutralization
  - 3. Typical Circuits
  - 4. Varactor Multipliers

V. RF Oscillators 9
- A. Oscillation Principles
- B. Basic Oscillator Circuits
  - 1. Armstrong Oscillator
  - 2. Hartley Oscillator
  - 3. Colpitts Oscillator
  - 4. Ultra-audion Oscillator
  - 5. Class Oscillator
  - 6. TPTG Oscillator
  - 7. Grid-Leak Bias
  - 8. Shunt-Fed and Series-Fed Circuits
- C. Crystal Oscillators
  - 1. Crystal Cuts
  - 2. Temperature Effects
  - 3. Electrical Characteristics
  - 4. Typical Circuits

6

VI. AM Transmitters
- A. Principles of Amplitude Modulation
  1. Effects of the Modulating Signal
  2. Percent Modulation
  3. Frequency Components
  4. Vector Distribution and Sidebands
  5. Power Distribution in the AM Wave
- B. Plate Modulation
  1. Basic Principles
  2. Heising Modulator
  3. Typical Plate Modulation Circuits
- C. Other Modulator Circuits
  1. Grid Bias Modulation
  2. Cathode Modulation
- D. Amplitude Demodulation
  1. Demodulation Principles
  2. Diode Detectors
  3. Additional AM Detectors
- E. AM Receivers
  1. Receiver Comparison Factors
  2. TRF Receivers
  3. Superheterodyne Receivers
  4. Receiver Alignment Techniques

6

VII. Frequency Modulation Principles
- A. FM Basics
  1. Modulation Level
  2. FM Waveform Components
  3. FM Waveform Power Relations
  4. FM Bandwidth Requirements
  5. Indirect FM Via Phase Shifting
  6. Interference Suppression
- B. FM Reception
  1. Tuner Classifications
  2. RF Amplifiers
  3. Frequency Conversion
  4. Additional Receiver Circuits
- C. FM Alignment Techniques
  1. Steady Frequency IF Alignment
  2. Sweep Frequency IF Alignment
  3. Ratio Detector and Discriminator Alignment
  4. Front End Alignment
- D. FM Transmitters
  1. Direct FM Transmitters
  2. Frequency Modulation Via Phase Modulation
  3. Armstrong FM System
  4. Balanced Modulators

48

LABORATORY

1.	Parallel and Series-Resonant Circuits	3
2.	Low-Pass and High-Pass L-Section Filters	3
3.	Common Emitter Tuned RF Amplifier	3
4.	Common Base Tuned RF Amplifier	3
5.	LC Common Base Oscillator	3

6.	Class C RF Power Amplifier	3
7.	Linear RF Power Amplifier	3
8.	Common Emitter RF Mixer	3
9.	Common Emitter IF Amplifier	3
10.	Amplitude Modulation Characteristics	3
11.	AM Diode Detectors	3
12.	Frequency Modulation Characteristics	3
13.	Direct FM Modulation	3
14.	Indirect FM (Phase Shift) Modulation	3
15.	Single Sideband Techniques	3
16.	Multiplexing Techniques	3

Task 7: Communication Systems II

Performance Objective:

The learner will be given certain design parameters along with a desired response that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot, and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level with the 80 percent level being considered successful. This will be a written exam lasting two hours.

Performance Guide: THEORY

	Suggested Hours
I. Transmission Lines	6
A. Basic Principles	
1. Fundamentals	
2. Characteristic Impedance	
3. Losses	
4. Standing Waves	
5. Quarter and Half Wavelength Lines	
6. Reactance	
B. Smith Chart	
1. Fundamentals	
2. Problem Solution	
C. Components	
1. Double Stub	
2. Directional Couplers	
3. Baluns	
4. Slotted Line	
II. Radiation and Wave Propagation	6
A. Electromagnetic Radiation	
1. Fundamentals	
2. Effects of the Environment	
B. Propagation of Waves	
1. Ground Waves	
2. Sky Waves	
3. Space Waves	
4. Tropospheric Scatter	
5. Extraterrestrial Communications	

III. Antennas 9

- A. Basic Considerations
  - 1. Radiation Mechanism
  - 2. Elementary Doublet
- B. Wire Radiators
  - 1. Current and Voltage Distributions
  - 2. Resonant Antennas
  - 3. Nonresonant Antennas
- C. Terms and Definitions
  - 1. Gain
  - 2. Resistance
  - 3. Bandwidth, Beamwidth, and Polarization
- D. Effects of Ground on Antennas
  - 1. Ungrounded Antennas
  - 2. Grounded Antennas
  - 3. Effects of Antenna Height
- E. Antenna Coupling at Medium Frequencies
  - 1. Selection of Feed Point
  - 2. Couplers
- F. Directional High-Frequency Antennas
  - 1. Dipole Arrays
  - 2. Folded Dipole
  - 3. Rhombic
- G. Microwave Antennas
  - 1. Antennas with Parabolic Reflectors
  - 2. Horn Antennas
  - 3. Lens Antennas
- H. Wideband and Special Purpose Antennas
  - 1. Folded Dipole
  - 2. Helical
  - 3. Discone
  - 4. Log-Periodic
  - 5. Loop

IV. Waveguides, Resonators, and Components 3

- A. Rectangular Waveguides
  - 1. Reflection of Waves from a Conducting Plane
  - 2. The Parallel-Plane Waveguide
  - 3. Rectangular Waveguides
- B. Circular and Other Waveguides
  - 1. Circular Waveguides
  - 2. Other Types of Waveguides
- C. Waveguide Coupling, Matching, and Attenuation
  - 1. Methods of Exciting Waveguides
  - 2. Waveguide Joints
  - 3. Basic Accessories
  - 4. Multiple Junctions
  - 5. Impedance Matching and Tuning
- D. Cavity Resonators
- E. Auxiliary Components
  - 1. Directional Couplers
  - 2. Isolators and Circulators
  - 3. Mixers, Detectors, and Detector Mounts
  - 4. Switches

V. Microwave Tubes and Circuits 6
- A. Microwave Triodes
  - 1. High-Frequency Limitations of Vacuum Tubes
  - 2. UHF Triodes and Circuits
- B. Multicavity Klystron
- C. Reflex Klystron
- D. Cavity Magnetron
- E. Traveling-Wave Tube (TWT)

VI. Semiconductor Microwave Devices 6
- A. Transistors
  - 1. High-Frequency Limitations
  - 2. UHF and Microwave Transistors
- B. Varactors and Multipliers
  - 1. Varactor Diodes
  - 2. Varactor Multipliers
- C. Parametric Amplifiers
- D. Tunnel Diodes
  - 1. Oscillators
  - 2. Amplifiers
- E. Bulk Effects
  - 1. Gunn Effect and Diodes
  - 2. LSA Mode and Diodes
- F. Other Microwave Diodes
  - 1. IMPATT Diodes
  - 2. PIN Diodes
- G. Stimulated-Emission Devices
  - 1. Maser
  - 2. Laser

VII. Microwave Measurements 6
- A. Measurement of Power and Attenuation
  - 1. Low Powers
  - 2. Medium and High Powers
  - 3. Attenuation
- B. Frequency and Wavelength Measurements
  - 1. Frequency
  - 2. Wavelength
- C. Measurement of Impedance and Matching
  - 1. SWR
  - 2. Impedance
- D. Reflectionary and Sweep Techniques
  - 1. Reflection Coefficient and Return Loss
  - 2. Reflectometer Sweep Techniques
  - 3. Time-Domain Reflectometry
- E. Measurement of Component Characteristics
  - 1. Ferrite Components
  - 2. Direction Couplers
  - 3. Antenna Measurements
  - 4. Measurement of Q and Phase Shift

VIII. Radar Systems 6
- A. Basic Principles
- B. Pulsed Systems
  - 1. Basic Pulsed Radar System
  - 2. Antennas and Scanning
  - 3. Display Methods
  - 4. Pulsed Radar Systems
  - 5. Moving Target Indications (MTI)
  - 6. Radar Beacons

C. CW Systems
   1. Doppler Radar
   2. Frequency-Modulated CW Radar

TOTAL 48

LABORATORY

1.	Transmission Line Characteristics	3
2.	Transmission Line SWR Measurements	6
3.	Reflex Klystron Characteristics	3
4.	Smith Chart Applications	6
5.	Microwave Power Measurement	3
6.	Microwave Frequency Measurements	3
7.	Microwaves in Free Space	3
8.	Basic Antenna Characteristics	3
9.	Yagi Antenna Characteristics	3
10.	LPDA Antenna Characteristics	9
11.	RF Propagation Characteristics	3
12.	US Frequency Spectrum Allocations	3

Task 8: Industrial Electronics

Performance Objective:

The learner will be given certain design parameters along with a desired response that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

. the completion of the task, the learner will be tested to ascertain his achievement level with the 80 percent level being considered successful. This will be a written exam lasting two hours.

Performance Guide: THEORY

		Suggested Hours
I.	DC Power Supplies	4
	A. Rectification Circuits	
	1. Single Phase Half-Wave Rectification	
	2. Single Phase Full-Wave Rectification	
	3. Three Phase Rectification	
	4. Six Phase Star Rectifier	
	B. Filtering and Regulation	
	1. Basic Filtering Systems	
	2. Regulation Principles	
	3. Protection Circuitry	
II.	PNPN Control Circuits	6
	A. SCR Circuits	
	1. Blocking and Triggering	
	2. Turn-On and Turn-Off of SCR's	
	3. Power Control Applications	
	4. Protection Circuits	
	B. TRIAC Circuits	
	1. Blocking and Triggering	
	2. Turn-On and Turn-Off	
	3. Power Control Applications	
	4. Protection Circuits	
	C. Triggering Circuits for Thyristers	
	1. UJT and PUT Relaxation Oscillators	
	2. DIAC Triggering Characteristics	
III.	Phase Shift Controls	6
	A. Passive Phase-Shifting Circuits	
	1. 90 Degree Phase-Shift Control	
	2. 180 Degree Phase-Shift Control	
	3. Phase Shift Control Design	

B. Active Phase-Shifting Circuits
   1. Relaxation Oscillator Design
   2. DIAC Phase-Shift Design

IV. Electronic Control of Motors — 6
   A. Electric Motor Characteristics
      1. Split-Phase Induction Motors
      2. Capacitor and Shaded-Pole Motors
      3. Universal, Polyphase Induction and Synchronous Motors
      4. Series-and Shunt-Wound DC Motors
      5. Digital Stepper Motor
   B. Fractional Horsepower AC Motor Control
      1. High Torque Speed Characteristics
      2. TRIAC Control
   C. Adjustable Speed DC Motor Control
      1. Fractional Horsepower Speed Controls
      2. DC Shunt-Motor Control

V. Timing and Active Time Delays — 4
   A. Analog Time Delay Systems
   B. Digital Time Delay Systems
   C. Timing Sources
      1. Schmitt Trigger
      2. Astable Multivibrator
      3. IC Timers (555 and 74121)

VI. Transistorized Industrial Control Relays — 4
   A. Solid State Photoelectric Control
      1. Photoresistance Cell Control Circuits
      2. Phototransistor and Diode Control Circuits
   B. LED Photoelectric Control
      1. LED Control Circuits
      2. Optocoupler and Isolator Circuits

VII. Digital Sequence Control — 6
   A. Relay Ladder Diagram
   B. Design of Sequencing Systems
      1. "Common Sense" Approach
      2. Sequence Chart
   C. Solid-State Logic Sequencing Systems
      1. GE Transistorized Static Control
      2. DEC's K-Series Logic
   D. The Programmable Controller

TOTAL — 36

LABORATORY

1. Electronic Regulator and Protection Circuits — 3
2. Three-Phase Rectifier Circuits — 3
3. Phase-Shift Control of SCR and TRIAC — 3
4. Relaxation Oscillators for Triggering Thyristors — 3
5. DIAC Triggering of Thyristors — 3
6. RL Phase-Shifting Circuits — 3
7. RC Phase-Shifting Circuits — 3
8. DC Shunt-Motor Operation — 3
9. SCR Automatic Motor Speed Control — 3
10. Commercial Transistor Motor Control — 3

11.	UJT-Controlled SCR Time-Delay Circuits	3
12.	Integrated Circuit Time-Delay Relay	3
13.	Transistor Time-Delay Relay	3
14.	Photoelectric Control Circuit Design	3
15.	Relay Ladder Control Circuit Design	3
16.	Digital Sequence Control Design	3

Task 9: Instrumentation and Measurements

Performance Objective:

The learner will be given certain design parameters along with a desired response that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level with the 80 percent level being considered successful. This will be a written exam lasting two hours.

Performance Guide: THEORY

		Suggested Hours
I.	Basic Measuring Instruments	8
	A. Probability and Error Analysis	
	1. Error Analysis	
	2. Statistical Analysis	
	B. Passive Ammeters, Voltmeters and Ohmmeters	
	1. Ammeter Shunting Techniques	
	2. Voltmeter Multiplier Techniques	
	3. Ohmmeter Circuitry	
	C. AC Voltmeters	
	1. Iron-Vane Voltmeters	
	2. Electrodynometer Voltmeters	
	3. Rectifier-Type AC Voltmeters	
II.	Electronic Instruments for Electrical Parameter Measurements	6
	A. Vacuum-Tube Voltmeters (Analog)	
	1. DC and AC Voltmeters	
	2. Balanced-Bridge Voltmeter	
	B. Transistorized Voltmeters	
	1. Transistor Bridge Circuits	
	2. FET Bridge Voltmeters	
	C. Digital Voltmeters	
	1. Ramp-Type DVM	
	2. Integrating-Type DVM	
III.	Potentiometer Circuitry and Applications	2
	A. Potentiometer Basics and Multirange Potentiometers	
	B. The Voltbox	

C. Calibration of Voltmeters and Ammeters
D. Self-Balancing Potentiometer

IV. Bridge-Type Instruments — 6
A. Resistance Bridges
1. Bridge Balance Requirements
2. The Wheatstone Bridge
3. Bridge-Type Indicating Instruments
B. Capacitance Bridges
1. Basic Capacitance Bridge
2. Schering Bridge
3. Power Factor Measurements
C. Inductance Bridges
1. Review of Inductor Characteristics
2. Maxwell and Hay Bridges
3. The Owen Bridge
D. Impedance Bridges
1. Basic Impedance Bridge
2. Capacitance and Inductance Measuring Functions
3. Principles of the Q-Meter

V. Electronic Display Instruments — 4
A. Basic Oscilloscope Circuitry
1. Cathode Ray Tube Characteristics
2. Basic Oscilloscope Operation
B. General Purpose Oscilloscopes
1. Time-Base Operation
2. Vertical and Horizontal Amplifiers
C. Triggered-Sweep Oscilloscopes
1. Circuit Operation
2. Calibrator Section
3. Probes for Oscilloscopes

VI. Signal Generators and Waveform Analyzers — 3
A. Oscillators
B. Signal Generators
C. Function Generators
D. Wave Analyzers
E. Distortion Analyzers

VII. Frequency and Time Measuring Instruments — 2
A. The Decade-Counting Unit
B. The Control Gate
C. The Time Base and Associated Circuitry
D. Frequency and Period Measurements

VIII. Transducers in Instrument Systems — 2
A. Classification of Transducers
B. Transducer Selection
C. Displacement, Temperature and Optoelectronic Transducers
D. Magnetic Measurements

IX. Data Conversion and Acquisition Systems — 3
A. Instrumentation Systems
B. Magnetic Tape Recorders
C. D/A and A/D Converters
D. Multiplexing Systems

LABORATORY

		Suggested Hours
1.	Statistical Analysis	3
2.	Ammeter and Voltmeter Circuitry	3
3.	Ohmmeter Circuitry	3
4.	Rectifier-Type AC Voltmeter Design	3
5.	Transistor Bridge Voltmeter	3
6.	Basic Digital Voltmeter	3
7.	Potentiometer Calibration Techniques	3
8.	Wheatstone Bridge Design	3
9.	Capacitance and Inductance Comparison Bridges	3
10.	Uses of the Q-Meter	3
11.	Uses and Applications of Laboratory Oscilloscopes	3
12.	Design and Calibration of Oscilloscope Probes	3
13.	Uses of Waveform Generators and Analyzers	3
14.	Uses and Applications of Frequency Counters	3
15.	Transducer Systems in Industry	3
16.	A/D and D/A Converters	3

Task 10: Electronic Design

Performance Objective:

The learner will be given certain design parameters along with a desired response that applies to a particular circuit or system contained in any of the unit topics described in the performance guide. Using these parameters, the learner will then design and fabricate a circuit or system that yields the desired response in a laboratory situation.

In addition to the design and fabrication experience, the learner will be given a faulty circuit or system and its associated symptoms. The learner will then diagnose, troubleshoot and correct these faults, thereby restoring the circuit or system to proper operating condition.

Criterion-Referenced Measure:

At the completion of the task, the learner will be tested to ascertain his achievement level with the 80 percent level being considered successful. This will be a written exam lasting two hours.

Performance Guide: THEORY

		Suggested Hours
I.	Student-Advisor Conferences The student will have continual conferences with his project advisor throughout the duration of the project. The problems encountered by the student will be discussed with the advisor who will in turn make suggestions and recommendations to the student concerning his project.	36
II.	Design Phase A. Design Objective--Determined by mutual agreement between the student and the project advisor B. Research of Literature C. Preliminary Circuit Design D. Preliminary Circuit Breadboarding and Testing E. Circuit Modifications	16
III.	Product Fabrication Phase The student assembles the final product in the appropriate package, using modern, up-to-date fabrication and assembly techniques.	16
IV.	Product Testing Phase The student will now test the final product to make sure it meets the appropriate design parameters. Next, the project advisor tests the final product and gives his approval.	10
V.	Final Report The final report follows the quidelines set up for writing a thesis. It will outline the design, development, materials used, fabrication techniques, testing procedures, conclusions and recommendations regarding the product. The report is diagrammatically and graphically illustrated. Photographs of the product are also included.	6

Auxiliary Task 1: Drafting for Electronics

Performance Guide:

		Suggested Hours
	THEORY	
I.	Fundamentals	2
	A. Mechanical Drawing Equipment	
	1. Use and Care	
	2. Electronic Symbol Templates	
	3. Alphabet of Lines	
	B. Sheet Layouts	
	1. Papers, Sizes and Border Lines	
	2. Nameplate, Blocks and Scales	
	3. Centering and Procedure	
	C. Lettering	
	1. Types	
	2. Freehand Techniques	
	3. Use of Lettering Templates	
	4. Elementary Geometrical Constructions	
II.	Sketching and Shape Description	3
	A. Techniques of Freehand Sketching	
	1. Measuring Subject	
	2. Block Drawings and Proportions	
	3. Detailing	
	B. Theory of Projection	
	1. Isometric	
	2. Oblique	
	3. Sketching	
	C. Multiview Drawing	
	1. Principles	
	2. Relationship of Views	
	3. Selection of Views	
	4. Treatment of Invisible Surfaces	
	5. Auxiliary Views	
	D. Sectional Views	
	1. Half Sections	
	2. Full Sections	
	3. Broken Sections	
III.	Dimensioning	2
	A. General Dimensioning	
	B. Formulation and Placement of Shop Notes	
	C. Tolerances	
	1. Purpose	
	2. Terminology	
IV.	Pictorial Drawing	2
	A. Isometric Drawing	
	1. Position of Axes	
	2. Steps in Construction	
	B. Shading	
	1. Shade Lines	
	2. Surface Shading with Lines	
	3. Stippling	

V.	Working Drawings	1
	A. Detail Drawings	
	1. Purpose	
	2. Construction	
	B. Assembly Drawings	
	1. Types	
	2. Uses	
	3. Parts Lists	
VI.	Electrical Circuits	3
	A. Electrical Symbols	
	1. Electronic Symbols	
	2. Logic Symbols	
	3. Architectural Symbols	
	4. Power Symbols	
	5. Symbol Guides	
	6. Relays	
	B. Schematic Diagrams	
	1. Schematic Layouts	
	2. Computer Flow Charting	
	C. Wiring Diagrams	
	1. Industrial	
	2. Communication	
VII.	Electrical Layouts	3
	A. Layouts	
	1. Chassis	
	2. Panel	
	3. Laboratory	
	4. Printed Circuit	
	5. Integrated Circuits	
	TOTAL	16

Auxiliary Task 2: Technical Mathematics I (Algebra and Trigonometry)

Performance Guide:

		Suggested Hours
	THEORY	
I.	Fundamentals	8
	A. Numbers and Literal Symbols	
	B. Fundamental Laws of Algebra	
	C. Law of Signs	
	D. Operations with Zero	
	E. Exponents and Radicals	
	F. Addition and Subtraction of Algebraic Expressions	
	G. Multiplication and Division of Algebraic Expressions	
	H. Equations and Formulas	
II.	Functions and Graphics	5
	A. Functions	
	B. Rectangular Coordinates	
	C. Graphing Functions	
	D. Zeros of a Function	
	E. Polar Coordinates	
III.	Trigonometric Functions	5
	A. Angles	
	B. Right Triangle	
	C. Trigonometric Functions	
	D. Values of Trigonometric Functions	
	E. Use of Trigonometric Tables	
	F. Trigonometric Applications of the Slide Rule	
IV.	Linear Equations and Determinants	6
	A. Linear Equations	
	1. Solutions of Two Equations with Two Unknowns	
	a. Graphical	
	b. Algebraic	
	c. By Determinants	
	2. Solutions of Three Equations with Three Unknowns	
	a. Graphical	
	b. Algebraic	
	c. By Determinants	
V.	Factoring and Fractions	6
	A. Factoring	
	B. Simplifying Fractions	
	C. Addition and Subtraction of Fractions	
	D. Multiplication and Division of Fractions	
VI.	Quadratic Equations	4
	A. Definitions	
	1. Factoring	
	2. Completing the Square	
	3. Quadratic Formula	
	4. Graphical	
VII.	Trigonometric Functions of Any Angle	4
	A. Signs of Trigonometric Function	
	B. Radians	
	C. Applications of Radians	

	D. Trigonometric Functions of Any Angle	
	E. Further Slide Rule Applications	
VIII.	Vectors and Triangles	6
	A. Vectors	
	B. Applications of Vectors	
	C. Oblique Triangles	
	D. Law of Sines	
	E. Law of Cosines	
IX.	Graphs of the Trigonometric Functions	6
	A. Graphs of Y=A sin x and Y=A cos x	
	B. Graphs of Y=A sin bx and Y=A cos bx	
	C. Graphs of Y=A sin (bx + c) and Y=A cos (bx + c)	
	D. Graphs of Y=tan x, Y=cot x, Y=sec x, Y=csc x	
	E. Applications of the Trigonometric graphs	
	F. Composite Trigonometric Curves	
X.	Exponents and Radicals	5
	A. Positive Integers as Exponents	
	B. Zero and Negative Integers as Exponents	
	C. Fractional Exponents	
	D. Simplest Radical Form	
	E. Addition and Subtraction of Radicals	
	F. Multiplication and Division of Radicals	
XI.	j Operator	5
	A. Imaginary and Complex Numbers	
	B. Operations with Complex Numbers	
	C. Graphical Representation of Complex Numbers	
	D. Polar Form of a Complex Number	
	E. Products, Quotients, Powers, and Roots of Complex Numbers	
XII.	Logarithms	5
	A. Exponential and Logarithmic Functions	
	B. Graphs of $Y=b^x$ and $Y=\log b^x$	
	C. Properties of Logarithms	
	D. Logarithms to the Base 10	
	E. Computations Using Logarithms	
	F. Logarithmic Applications of the Slide Rule	
XIII.	Solving Equations and Systems of Equations	5
	A. Graphical Solution of Systems of Equations	
	B. Algebraic Solution of Systems of Equations	
	C. Equations in Quadratic Form	
	D. Equations with Radicals	
	E. Exponential and Logarithmic Equations	
XIV.	Properties of the Trigonometric Functions	6
	A. Fundamental Trigonometric Identities	
	B. Sine and Cosine of the Sum and Difference of Two Angles	
	C. Double and Half Angle Formulas	
	D. Trigonometric Equations	
XV.	Inverse Trigonometric Functions	4
	A. Inverse Trigonometric Functions	
	B. Principal Values	
	C. Graphs of the Inverse Trigonometric Functions	
	TOTAL	80

Auxiliary Task 3: Technical Mathematics II (Analytic Geometry and Calculus)

Performance Guide:

		Suggested Hours
	THEORY	
I.	Elements of Analytic Geometry	8
	A. Straight Line	
	B. Circle	
	C. Parabola	
	D. Ellipse	
	E. Hyperbola	
	F. Polar Coordinates	
	G. Areas Under Curve	
II.	Differentiation	16
	A. Limits	
	B. Slope of a Tangent to a Curve	
	C. Derivatives	
	D. Derivatives of Polynomials	
	E. Derivatives of Products and Quotients	
	F. Derivatives of a Power	
	G. Curve Tracing	
	H. Maximum and Minimum	
III.	Integration	16
	A. Differentials and Inverse Differentiation	
	B. Indefinite Integral	
	C. Definite Integral	
	D. Areas by Integration	
	E. Volumes by Integration	
	F. Applications of the Integral	
IV.	Differentiation of Transcendental Functions	8
	A. Derivatives of the Sine and Cosine	
	B. Derivatives of the Other Trigonometric Functions	
	C. Derivatives of the Inverse Trigonometric Functions	
	D. Derivatives of the Logarithmic Function	
	E. Derivative of Exponents	
	F. Applications	
V.	Integration Techniques	8
	A. General Exponential Formula	
	B. Logarithmic and Exponential Form	
	C. Basic Trigonometric Forms	
	D. Integration by Parts	
	E. Integration by Substitution	
	F. Use of the Tables	
VI.	Fourier Analysis	8
	A. Introduction	
	B. Developing the Fourier Series	
	C. Even and Odd Functions	
	D. Application	
	TOTAL	64

Auxiliary Task 4: Technical Physics I (Properties of Matter and Mechanics)

Performance Guide:

Suggested Hours

THEORY

I. Introduction — 2
   A. Physics: A Study of Matter and Energy
      1. Matter
         a. Solid
         b. Liquid
         c. Gas
      2. Energy
         a. Forms
            (1) Potential
                (a) Chemical
                (b) Position
                (c) Nuclear
            (2) Kinetic
         b. Conversion
   B. Mathematics for Physics
      1. Decimals
      2. Exponents
      3. Trigonometric Functions
      4. Graphs, Design and Interpretation
      5. Slide Rule
   C. Symbols and Terms
   D. Problem Solving

II. Measurement — 3
   A. Fundamental Units of Measurement
      1. Length
         a. English
         b. Metric
         c. Conversion Factors
      2. Mass
         a. English
         b. Metric
         c. Conversion Factors
      3. Time
   B. Secondary Units of Measure
      1. Area
         a. English
         b. Metric
      2. Volume
         a. English
         b. Metric
   C. Measuring Devices and Techniques
      1. Length
         a. Scaled Straight Edge
         b. Calipers and Dividers
         c. Micrometer Caliper
         d. Vernier Caliper
         e. Gauge Blocks
         f. Optical Flats
      2. Area

3. Volume
4. Mass
5. Force--Spring Balance
6. Time
7. Direction
    a. Units
    b. Measurement
    c. Scales

III. Atoms and Molecules 2
- A. Structure of Matter
    1. Atoms
        a. Electron Orbits
        b. Nucleus
            (1) Protons
            (2) Neutrons
    2. Molecules
    3. Compounds
    4. Mixtures
- B. States of Matter
    1. Solid
    2. Liquid
    3. Gas
- C. Forces Among Molecules
    1. Cohesion
    2. Adhesion
    3. Capillary Action
- D. Molecules in Motion
    1. Brownian Movement
    2. Diffusion
    3. Osmosis
    4. Kinetic Theory

IV. Properties and Phenomena of Solids 3
- A. Density
    1. Mass
    2. Weight
- B. Elasticity
- C. Stress
    1. Tensional
    2. Compressional
    3. Torsional
    4. Shear
    5. Bending
- D. Strain
- E. Hooke's Law
- F. Young's Law
    1. Ratio of Stress to Strain
    2. Elastic Limit
- G. Hardness, Malleability, Ductility, and Tensile Strength
- H. Effect of Heat
    1. Linear Expansion
    2. Area Expansion
    3. Volumetric Expansion

V. Properties and Phenomena of Liquids 3
- A. Pressure
    1. Measurement
    2. Calculation

3. Pascal's Vases
4. Head

B. Forces in Fluids
1. Archimedes' Principle
2. Bernoulli's Principle

C. Physical
1. Viscosity
2. Volatility
3. Specific Gravity
4. Density

D. Hydraulics
1. Hydraulic Press
2. Pumps
a. Centrifugal
b. Lift
c. Force
d. Gear
3. Motors (Hydraulic Driven)

VI. Properties and Phenomena of Gases — 3
A. Elasticity and Compressibility
1. Boyle's Law
2. Charles' Law
3. General Gas Law

B. Pressure
1. Vacuum
2. Atmospheric
3. Absolute

C. Pressure Gauge
1. Barometer
2. Bourdon Gauge

VII. Vectors and Graphic Solutions — 2
A. Vectors
B. Graphic Solutions

VIII. Force and Motion — 3
A. Force
1. Definition
2. Force of Gravitation
a. Newton's Law of Universal Gravitation
b. Relation of Gravity to Weight
c. Means of Measuring

B. Concept of Motion
1. Velocity
2. Acceleration
3. Velocity and Acceleration
4. Distance and Acceleration
5. Acceleration Due to the Force of Gravity

C. Newton's Laws of Motion
1. Inertia
2. Acceleration
3. Action and Reaction

IX. Work, Energy and Power — 3
A. Work
1. Definition
2. Units of Work
a. Metric
b. English

B. Energy
1. Classification
a. Kinetic Energy
b. Potential Energy
2. Measurement of Energy
a. Metric
b. English
3. Energy and Its Transformation
a. Original Sources
b. Conversion to Other Forms
4. Law of Conservation of Energy
C. Momentum
1. Impulse
2. Impact of Moving Fluids
3. Momentum and Newton's Third Law
a. Law of Conservation of Momentum
b. Rockets and Jets
D. Power
1. Definition
2. Units of Power
3. Efficiency
4. Measuring Horsepower
a. Prony Brake
b. Electrical Dynamometer
c. Hydraulic Dynamometer

X. Analysis of Basic Machines and Friction 5
A. Basic Machines
1. Lever
a. Mechanical Advantages
b. Examples and Types
2. Inclined Plane
a. Vectorial Analysis
b. Applications
3. Hydraulic Press
B. Friction
1. Nature of Friction
2. Analyzing Frictional Forces
3. Coefficient of Friction
4. Effect of Friction on Machines
5. Mechanical Advantage and Efficiency of Machines
C. Simple Machines
1. Wedge
2. Screws
3. Wheel and Axle
4. Pulleys
5. Gears
D. Compound Machines

XI. Rotation, Torque and Power Transmission 3
A. Rotary Motion
B. 1. Rotation as Opposed to Translation
2. Angular Measurements
B. Torque
1. Units of Torque
2. Contrast to Work
3. Applications

C. Power Transmission
   1. Work and Power in Rotary Motion
   2. Drive Shafts
D. Centripetal Force
   1. Uniform Circular Velocity
   2. Circular Acceleration
   3. Relationship of Newton's First Law of Motion
   4. Relationship of Newton's Second Law of Motion
   5. Applications
E. Centrifugal Force
   1. Relationship of Newton's Third Law of Motion
   2. Industrial Applications

TOTAL 32

Auxiliary Task 5: Technical Physics II (Heat, Light and Sound)

Performance Guide:

Suggested Hours

THEORY

I. Temperature and Heat — 6
   A. Temperature
      1. Definition
      2. Measurement
         a. English
            (1) Farenheit
            (2) Rankine
         b. Metric
            (1) Celsius (Centigrade)
            (2) Kelvin or Absolute
         c. Conversion
         d. Thermometers
            (1) Liquid
            (2) Gas
            (3) Resistance
            (4) Thermoelectric
            (5) Pyrometer
               (a) Optical
               (b) Radiation
   B. Heat
      1. Definition
      2. Contrasted with Temperature
      3. Measurement
         a. English
            (1) British Thermal Unit (BTU)
         b. Metric
            (1) Calorie (cal)
         c. Calorimeter
      4. Specific Heat and Thermal Capacity
      5. Law of Heat Exchange
      6. Change of State
         a. Latent Heat of Fusion
         b. Melting and Freezing
         c. Latent Heat of Vaporization
         d. Evaporation, Boiling and Condensation
         e. Effect of Pressure
      7. Heat Transfer
         a. Definition
         b. Direction
         c. Methods
            (1) Convection
               (a) Forced
               (b) Natural
            (2) Radiation
               (a) Light and Dark Surfaces
               (b) Polished and Dull Surfaces
            (3) Conduction

II. Sound and Wave Motion 8
- A. Wave Characteristics
  - 1. Source
  - 2. Frequency
  - 3. Pitch
  - 4. Loudness and Intensity
  - 5. Quality
  - 6. Length
  - 7. Velocity
    - a. Effect of Medium
    - b. Effect of Temperature
- B. Transverse Waves
  - 1. Motion
  - 2. Applications
- C. Longitudinal Waves
  - 1. Rarefaction
  - 2. Condensation
- D. Musical Tones
  - 1. Pitch
  - 2. Wave Characteristics of Harmony
- E. Calculations
- F. Technical Applications of Sound Waves
  - 1. Reflection
    - a. Measurements
    - b. Ultrasonics
  - 2. Refraction
  - 3. Seismographic Applications
  - 4. Absorption of Sound
    - a. Coefficients
    - b. Materials
  - 5. Recording and Reproduction of Sound
    - a. Wax
    - b. Wire
    - c. Tape
    - d. Film
  - 6. Resonance

III. Light and Illumination 8
- A. Early Theories
- B. Present Theories Accounting for Light Properties
  - 1. Wave
  - 2. Quantum
- C. Velocity of Light
- D. Illumination Calculations
  - 1. Intensity
    - a. Photometer
    - b. Foot Candle Meter
- E. Color
- F. Diffusion
- G. Ultraviolet Radiation
- H. Fluorescent Illumination

IV. Principles of Optical Measurement 6
- A. Light Rays and Beams
- B. Reflection of Light
  - 1. Diffused
  - 2. Regular
    - a. Images
    - b. Calculations of Angles

c. Optical Levers
(1) Calculations
(2) Sextant

3. Curved or Spherical Mirrors
a. Real and Virtual Images
(1) Concave
(2) Convex
b. Calculations
(1) Image Location
(2) Image Magnitude

C. Refraction of Light
1. Index
2. Calculations
3. Critical Angles
4. Lenses
a. Types
b. Terminology
c. Formation of Images
d. Calculations
(1) Image Location
(2) Power of Lenses
(3) Image Magnitude

D. Dispersion of Light
1. Prism
a. Color Spectrum
b. Angles of Deviation and Dispersion
2. Spectroscope
3. Spectrograph

E. Polarized Light
1. Theory
2. Detection
3. Applications

V. Atomic Energy 4
A. Nature of Atomic Energy
1. Early Concepts
2. Nineteenth-Century Discoveries
a. Dalton's Atomic Theory
b. Sir William Crookes' Cathode Rays
c. J. J. Thompson - Divisibility of Atoms
3. Early Twentieth-Century Discoveries
a. Robert A. Millikan - Measurement of Electrons
b. E. Goldstein and W. Wein - Discovery of Protons
c. Lord Rutherford and Niels Bohr - Planetary Concept
d. James Chadwick - Discovery of Neutrons
4. Atomic Weight and Number
5. Energy in the Atom
a. Einstein's Mass-Energy
b. Law of Conservation of Mass Energy
c. Experiment with Lithium
6. Atomic Disintegration
7. Atomic Bombardment
a. Cyclotron
b. Van de Graaf Generator
c. Betatron
8. Uranium Fission - Slow Neutron Bombardment
9. Fusion

B. Atomic Energy for Military Purposes
   1. Separation of U^{235} from U^{238}
   2. Fissionable Plutonium
C. Industrial Uses of Atomic Energy
   1. Plutonium Reactor and Power Developer
   2. Radioactive Isotopes

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